INTESTINAL OBSTRUCTIONS

A Physiological and Clinical Consideration with Emphasis on Therapy, Including Description of Operative Procedures

INTESTINAL
OBSTRUCTIONS

A PHYSIOLOGICAL *and* CLINICAL CONSIDERATION *with Emphasis on* THERAPY, *Including* DESCRIPTION *of* OPERATIVE PROCEDURES

By

OWEN H WANGENSTEEN, B A , M D , PH D

Professor of Surgery of the University of Minnesota and Surgeon in Chief of the University of Minnesota Hospital

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TO MY WIFE

PREFACE TO SECOND EDITION

THE GENEROUS reception accorded the first edition of this book, published now almost five years ago, prompts the writer to undertake its revision. That book published under the title of *The Therapeutic Problem in Bowel Obstructions*, was an outgrowth of the Samuel D. Gross Prize Award of the Philadelphia Academy of Surgery for 1935, and was published in compliance with stipulations of the Gross Prize.

The present edition is, in many respects, a new book. The difficulty of arrangement of subject matter encountered in the first edition, an occurrence which came about through supplementing the Gross Essay by additional related materials, has been done away with in the revision. The plan of this edition is a more natural one and the scheme employed for discussion of the subject matter permits its presentation under four distinct sections or parts, which are as follows: (1) The Effects of Obstruction; (2) General Diagnostic Considerations in the Recognition of Bowel Obstruction; (3) General Therapeutic Considerations in Its Management, and (4) The Special Obstructions.

It was the writer's intention to employ the chronological or historical method in discussing the experimental aspects of the bowel obstruction problem. It was found, however, that the mechanistic conception of the ill effects of intestinal obstruction developed in the Gross Essay of the first edition, served the writer's purpose best. The skeleton of that presentation has been preserved, therefore.

Special emphasis has been placed on the therapy of intestinal obstruction. In the first edition, considerable space was lent the conservative management of certain types of intestinal obstruction, by suction applied to an indwelling duodenal tube—then, a new form of therapy. In this edition an attempt has been made to secure a more even balance between operative and non operative forms of treatment. Intestinal intubation with the Miller Abbott tube, a technique developed since the publication of the first edition, is described. After an experience now of more than 10 years with conservative decompression—a method which has exerted, apparently, a material favorable influence upon the mortality of intestinal obstruction, the writer feels that, further general decrease of the risks of obstruction will come about largely through improvements in dealing with obstructed patients surgically. With that consideration in mind, and mindful also of the shortcomings of the suction method, great pains have been taken to attempt to describe, more adequately, satisfactory surgical procedures in the management of intestinal obstruction.

When the surgeon learns to decompress the distended bowel aseptically, at operation, only then will the mortality attending surgical intervention begin to exhibit palpable betterment. The uniformly low mortality rate in the group of cases treated successfully by the indwelling duodenal tube owes this accomplishment undoubtedly, to achieving decompression without peritoneal soiling. When conservative methods are persisted

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in, until the viability of the bowel is threatened or impaired seriously, the risks assumed are pyramided considerably Elaboration of safe and effectual means, which will permit dealing with the problem of distension, at operation, will make an important contribution to the therapy of intestinal obstruction

As in the first edition an attempt has been made to integrate clinical and roentgen evidence in the diagnosis of obstruction Suggestions that diagnosis may be made from x ray films alone, without the orientation afforded by clinical findings, this writer feels, are out of place A proper fusion of clinical and roentgen observations constitutes the best basis for sound interpretations and accurate diagnosis

Everyone is a debtor to his Profession It has been a pleasant and duteous task to record, in these pages, the writer's experience with the bowel obstruction problem—representing, in large measure, knowledge gained from others

Minneapolis, Minnesota

PREFACE TO FIRST EDITION

THIS ESSAY appears in print in compliance with one of the stipulations of the Samuel D Gross Prize Award It attempts to set forth in a concise manner the important aspects of the therapeutic problem in obstruction of the bowel as they appear to the writer It is more concerned with the problem of therapy as it relates to the subject of obstruction of the intestine in the broad sense than with special considerations peculiar to certain types of obstruction In essence, this essay is a brief digest of the writer's investigations and experience in the field of intestinal obstruction

The management of bowel obstruction has been the subject of several special treatises in various languages, it has been often a major theme for discussion at surgical congresses and symposia And rightfully so, for despite conspicuous improvement attending the results of treatment of many acute abdominal lesions, up until quite recently no similar progress could be boasted of in the management of acute intestinal obstruction It was lamented on every hand that fifty years of abdominal surgery, resplendent with brilliant achievements in many parts, had effected no material reduction in the mortality of bowel obstruction a satisfactory and adequate explanation appeared to have been found in the testimony of many experimental investigations which indicated the occurrence of abnormal absorption from the lumen of the obstructed bowel—a circumstance permitting inundation of the organism with profound and lethal toxins Many clinicians were quick to seize upon the toxic factor finding in this refuge some solace for their misgivings and an ample account for their poor results in the treatment of bowel obstruction

But slender support has been lent to the toxin absorption theory as the important factor in the cause of death in obstruction of the bowel by recent researches More and more it is becoming increasingly evident that the mechanical factors with which this essay aims in particular to deal are of the greatest consequence There is much yet to learn concerning the bodily upsets and disturbances which accompany obstruction of the bowel It is eminently significant and gratifying, however to know that therapy guided by an understanding of the lessons learned in the study and investigation of bowel obstruction has resulted in definite lowering of the mortality of the disease Successes with the treatment of late cases of obstruction lend their support to the denial that obstruction inevitably carries in its wake the absorption of fatal toxins

The mortality of the disease is to be sharply differentiated from the mortality of treatment That the latter has probably not been a negligible factor is to be inferred from the distinctly better results which are being obtained in many quarters by employment of therapeutic measures of proved value ~~The results of this study indicate that~~ relief of the obstruction by methods which preserve the sterility of the peritoneum inviolate is a consideration of first importance for a successful issue in the treatment of intestinal obstruction Any operation directed at release of the obstruc-

tion must be accomplished *aseptically* Escape of obstructed intestinal content at operation is synonymous with failure and death

In a short essay such as this, it is manifestly impossible to treat of bowel obstruction in all of its phases In the main, the writer has confined himself largely to those factors which bear most directly upon the therapeutic problem of obstruction If the publication of this manuscript were to await the correction of all shortcomings and imperfectiohs it undoubtedly would never see the light of day Some of its weaknesses have been repaired in part through supplementing the essay by additional chapters, in which it has been possible to relate in greater detail some of the more practical aspects of diagnosis and therapy and describe the principal features of special obstructions Inasmuch as the non-operative treatment of certain obstructions is advised herein, it was deemed essential to recount the deliberations upon which other lesions could be excluded satisfactorily, together with a brief recital of the writer's concept of the fundamental guiding principles, underlying the therapy of the common acute abdominal disorders The time has come when "acute abdomen" can no longer be considered synonymous with operation We stand on the brink of a new era in the surgery of acute abdominal afflictions in which surgical exploration will be done less frequently and in which the necessity for operation will be determined largely by what operation can accomplish

The writer regrets in particular that it has not been possible frequently to discuss many notable contributions in the measure which their importance merits If this effort which has been the agreeable labor of some leisure hours, aids in any manner in focusing attention upon the significant factors which relate to the therapeutic problem of bowel obstruction, the most sanquine hope of the writer for the essay will have been gratified fully If the recital of these experiences will lessen in a degree for others some of the difficulties through which the writer has passed in the management of patients with bowel obstruction, its writing will have been justified adequately

ACKNOWLEDGMENTS

THE STIMULUS for writing this book grew out of collaborative researches carried on in the Experimental Surgical Laboratory over a period of more than fifteen years on various aspects of the bowel obstruction problem Without the helpful and enthusiastic assistance of tho e collaborators, who are now more than a score in number, the materials for this volume would not have been available

It is also a pleasant duty to acknowledge the helpful support which the researches—from which source this book derives its inspiration—have received from the following sources

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The writer acknowledges gratefully the heightened value which the illustrations of operative procedures, made by Mr Herbert Hunter, have lent the manuscript The drawings carried over from the first edition were made by Miss Jean Hirsch To Mr Peder Lund the writer is indebted for a number of photographic reproductions To Dr Leo G Rigler, Professor of roentgenology, the writer is obligated for free access to x ray films

To Mrs Marion Jacobson, who has wrestled with the many trying tasks incidental to revision of the text the writer wishes to express his especial gratitude for her genuine interest and helpfulness in preparation of the manuscript for publication

Finally the writer conveys his thanks and appreciation to Mr Charles C Thomas for his cordial interest in every detail and problem relating to the publication of this volume

OWEN H WANGENSTEEN

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INTESTINAL OBSTRUCTIONS

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PART I

INTESTINAL OBSTRUCTIONS

INTRODUCTION

IT WAS undoubtedly the observation of Hartwell and Hoguet (1912), indicating that the lives of dogs, with high intestinal obstruction, could be prolonged considerably with the subcutaneous administration of saline solution, that intensified the interest of experimental workers more sharply in the bowel obstruction problem With clarification of the mystery, that veiled the true nature of the toxic death of dogs with high duodenal obstruction, by Gamble and his co workers (1925), the mechanism by which saline solution exerted this protection became apparent Failure of saline solution to afford the same character of protection to animals with ileal obstructions focused attention upon the great importance of the mechanical effects of distension upon the bowel wall It was Amussat (1839) who promulgated the thesis of absorption of an abnormal toxin from the obstructed bowel which caused death This century old concept of the lethal factor in bowel obstruction can not be put aside lightly Yet critical review of the available experimental work, that has been done upon the problem serves to emphasize the significant inter relationship of intra enteric tension, viability of the gut wall and the permeability factor Loss of viability of the bowel wall, opens up a new avenue of absorption, the transperitoneal migration of noxious agents from the bowel lumen

This is essentially the important lesson that experimentation, during the past fifteen years has taught Moreover, it is a precept which has most significant connotations for the clinician who cares for patients, with intestinal distension Long reaches of obstructed bowel, in which distension maintains a low but constant and steady increase of intraluminal pressure constitute the most frequent and difficult problem of therapy

After a decade's use of saline solution in the management of patients with acute intestinal obstruction following demonstration of its protective properties in high obstructions, McIver found no tangible evidence that the hospital mortality had been influenced favorably thereby Moreover with increasing appreciation and recognition of the great importance of the mechanical factors in the production of the ill consequences of obstruction and with development of satisfactory methods to combat distension a general lessening of the mortality of obstruction is becoming apparent McKittrick and Sarris (1940), in reviewing the experience of the Massachusetts General Hospital with the bowel obstruction problem, since the report of McIver (1934) state that for the first time in 40 years, a decline in the mortality of acute intestinal obstruction in that institution has become evident Similar reports have

sorption) is not significantly altered unless the viability of the bowel wall is impaired

The effect of sustained increases in intraluminal tension upon portal, femoral and inferior vena caval venous pressures will be pointed out It will be shown that large intestinal distensions impede the return of venous blood from the lower extremities with resultant increase of venous pressure and delay in circulation time How this segregating effect of distension upon the vascular system may occasion the loss of effective circulating blood volume will be described

It will be indicated further that, absorption by way of the mesenteric vessels is diminished under conditions of obstruction while lymphatic absorption appears increased It will be shown in strangulating obstruction that an important item in the lethal factor, apart from eventual death of the imprisoned intestinal loop, is loss of blood into the infarcted segment

With reference to timely recognition of bowel obstruction, it will be shown that upon establishment of the presence or absence of intestinal colic the diagnosis rests largely It will be indicated that, whereas vomiting is a prominent feature of mechanical obstruction of the small intestine frequently obstruction of the colon despite enormous distension, may be unassociated with vomiting It will be pointed out that feculent vomiting does not occur with uncomplicated obstruction of the large bowel but is frequently a sequel to high grade obstructions of the small intestine It will be shown that the interpretation of an x ray film of the abdomen correlated with the clinical findings enables one to determine readily, usually whether obstruction is present, whether it is complete or incomplete whether it concerns the small intestine or colon, and if in the small intestine whether the obstruction lies in the upper middle, or lower third of the gut and whether the obstruction is simple or strangulating in character It will be indicated that while these characters of obstruction may be defined readily, it is difficult, not infrequently, to ascertain the exact nature of a given obstruction without recourse to operation The varieties of obstruction giving rise to such difficulty of identification will be discussed briefly

In treating of the remedial agents of value in the relief of bowel obstruction, it will be shown that *saline solution aids in combating de* hydration but is without specific influence except in very high obstructions that transfusion of blood and plasma are of considerable value in strangulating obstructions where the blood loss into the infarcted segment may be great, also in high grade simple obstruction owing to diminution of effective circulating blood volume through the segregating influence of distension that transfusion of plasma may be a useful expedient It will be demonstrated that simple mechanical obstructions, and particularly when not complete may be relieved frequently by suction applied to an inlying duodenal tube without recourse to operation How frequent use of suction after abdominal operation has done away largely with the early postoperative obstructions will be recounted, together with other lessons that

emanated from a number of clinics, in many places, and lend encouragement to the hope that the forbidding mortality of the disorder will cease to exist

In the volume on *Vital Statistics of the United States for 1937* published by the Bureau of the Census in 1939, it is to be noted that appendicitis, the most important single cause of death amongst acute abdominal disorders, took a toll of 15 340 lives From intestinal obstruction alone 7 780 lost their lives Hernia took a toll of 5,331 lives, of which number, undoubtedly, a large proportion died of obstruction Further, of the 69 335 deaths due to malignancy of the digestive tract, 23,872 concerned the intestines, of this number 15,978 died of malignancies of the small and large intestine and 7 894 from malignancies of the rectum and anus Intestinal obstruction is often the immediate cause of death in intestinal neoplasms

The true importance of obstruction as a lethal factor is obviously difficult to assess with reasonable accuracy For distension and obstruction are terminal events in many abdominal tragedies Certain it is, that intestinal distension relates itself so intimately to a number of clinical conditions, as to constitute a therapeutic problem of major importance

Statement of the Problem

The general problem of bowel obstruction appears to fall quite naturally into four categories (1) elucidation of the effects of obstruction and particularly, the resultant consequences of distension upon the bowel wall, (2) definition of criteria by which timely recognition of bowel obstruction may be made (3) critical appraisal of the remedial agents directed at the relief of obstruction (4) special consideration of the various clinical types of obstruction

It is proposed to treat of the bowel obstruction problem with these particular items in mind Insofar, as intestinal distension is intertwined so inseparably with the manifestations of a number of abdominal disorders it is deemed advisable to discuss briefly the general fundamental diagnostic and therapeutic considerations, which underlie a number of acute abdominal catastrophies, not primarily obstructive in nature

With reference to the effects of distension, it is proposed to relate how the bowel becomes distended, what the elements are that contribute to the existence of distension and what their sources are The consequences of fluid losses in bowel obstruction will be reviewed The effects of distension upon the bowel will be traced and it will be indicated that such results are largely the result of increased intra enteric pressure The extent of these pressures in the experimental animal as well as in clinical cases of obstruction of both the small and large intestine will be related The significance of the ileocecal valve and sphincter in the development of high intra-colonic pressure will be shown There will be indicated the effects of obstruction upon the length, weight strength and histology of the bowel wall, how the blood supply to the intestine is influenced by increased intra-enteric pressure and, how in turn it influences the viability of the gut It will be shown that the permeability (transperitoneal ab-

the bowel has been impaired seriously Yet, too many patients are lost by surgical blunders This writer believes that the time is at hand, when concentration of the care of patients, presenting the effects of bowel obstruction, in the hands of a few persons in large hospitals, well oriented in all the therapeutic ramifications of the problem, will demonstrate effectually the validity of the premise, that *how* a procedure is carried out, is equally as important as *what* is done The truth of this statement has been shown amply in the risks of resections of the stomach and colon To be sure all the factors in a patient with acute intestinal obstruction are not controlled as readily, as in an operation of election Distension itself, constitutes a major surgical problem at operation frequently Surgical techniques must be devised which will permit dealing adequately and safely with distension at operation The patient whose distension remains unrelieved by attempts at accomplishing decompression by conservative means constitutes a serious problem for the surgeon The surgeon must learn to decompress the distended bowel at operation, in order that he may deal effectually in certain instances with the obstructing mechanism When the surgeon masters the art of dealing with the item of distension at operation without visible traces of soiling, preserving the sterility of the peritoneum another important milepost will be reached in the reduction of the mortality of intestinal obstruction The planned procedure guided by full knowledge of the physiologic principles involved and executed with infinite care and exacting precision will tell When the *mortality of treatment* is reduced to a minimum the unavoidable mortality, the only real measure of the *mortality of obstruction* per se, will become apparent

limitations and shortcomings, indications and *contraindications of the* method will be defined and the mechanics of its operation rationalized How the use of the balloon tipped Miller Abbott tube may pyramid usefulness of non operative decompression will be described

It will be shown that inhalation of high concentrations of oxygen, as described by Fine and his associates (1936), when used in conjunction with constant suction, applied to an indwelling duodenal tube, is an adjuvant measure *of value in augmenting the absorption of nitrogen from the* distended bowel Demonstration of the potential hazards of high concentrations of oxygen when administered uninterruptedly to normal dogs by Paine and his associates (1941), suggests that caution be observed, however, with administration over protracted periods of time

It will be indicated that, whereas suction makes the necessity for operative intervention less urgent in a number of obstructions, operation *continues still the most important agency in the relief of mechanical* obstructions Those obstructions which need immediate operation will be enumerated How the character of the obstruction influences the choice of operative procedure will be discussed The technical features of acceptable and satisfactory operative procedures directed at the relief of obstruction will be defined

Finally, the results of treatment will be recounted, first with reference *to accomplishments with the problem as a whole, subsequently, under* the special captions of the particular problems peculiar to each variety of obstruction achievement with the special obstructions will be discussed, in turn

More general recognition and appreciation of the effects of obstruction, better comprehension of the diagnostic criteria which contribute to recognition of the presence of obstruction and a more discerning appraisal of the worthwhile remedial agents in the relief of *obstruction—all of these* have had a part in the encouraging note that is becoming more palpably evident in the therapeutic problem of acute intestinal obstruction

The very grave nature of the difficulties which hedge about the management of patients, presenting strangulating obstruction with considerable distension—the chief stumbling block and the present most important cause of death are well known to all who have wrestled with the problem *One important source of difficulty is constituted by the absence of absolutely reliable* differential criteria to distinguish simple and strangulating obstructions Considered and careful adjudication of the problem presented by potential strangulating obstruction in the light of available differential criteria, alert attention to the great significance of blood and plasma losses in strangulating obstruction intelligent and discriminating use of conservative decompressive measures—all of these have an *important role* in contributing to the lowering of the mortality presented in patients with strangulating obstruction

In the immediate years which lie ahead, the factor which appears to afford greatest promise in dealing with the formidable and serious problem of strangulating obstructions is improvement in *the execution of surgical* maneuvers Surgical relief must come, of course before the viability of

of an obstructed loop Molnar (1909) has shown that section of the extrinsic nerves of the bowel results in a continuous secretory activity (paralytic secretion) and that the intravenous injection of meat extractives intensifies the activity of intestinal glands

For a number of reasons it would appear, therefore, that the alimentary fluids may be increased considerably in obstruction

TABLE I RATES OF TURN OVER OF WATER BY VARIOUS ORGANS IN A 70 KILO HUMAN INDIVIDUAL IN CUBIC CENTIMETERS PER 24 HOURS (Adolph)

Organs	Minimum	Liberal
Salivary glands	500	1 500
Stomach	1 000	2 400
Intestinal wall	700	3 000
Pancreas	700	1 000
Liver (bile)	100	400
Lymph	700	1 500
Total recovered by body	3 700	9 800
Kidneys	600	2 000
Colon (feces)	50	200
Skin (insensible loss)	350	700
Sweat glands	50	4 000
Mammary glands	0	900
*Total lost from body	1 050	7 800
Total turn-over	4 750	17 600

Adolph estimates loss by vaporization from lungs at 36 per cent of the extra renal losses

Doubt has been thrown upon the observations just referred to, in which it was indicated that the alimentary fluids secreted in obstruction exceed the normal by the experiments of Montgomery and Swindt (1934) In a study of the Effect of simple duodenal obstruction upon the combined gastric, pancreatic biliary, and duodenal ecretions" and the "Influence of closed intestinal loop strangulation on volume of the combined secretions ' these authors found no evidence of stimulation to excessive secretion on the contrary they found the fluid accumulations slightly less than in normal controls

The degree to which fluid accumulations contribute to distension in obstruction depends essentially on the location and the degree of the obstruction which in turn determine the fluid lost by vomiting The higher the obstruction the more readily are the intestinal fluids vomited Even in low obstructions in the small intestine, the vomiting of fluid may be great, but the residual accumulation of fluid with the effects of distension upon a long stretch of bowel wall will be greater than in high obstructions It should be stated here that the loss of fluid through the agency of vomiting in obstructions of the colon is negligible Such patients present evidence of gastric retention rarely, as will be shown subsequently

CHAPTER I

THE EFFECTS OF DISTENSION

A THE CHARACTER AND SOURCE OF THE DISTENSION

THE content of an obstructed bowel consists of fluid and gas which are present in varying amounts The extent to which each of these components contributes to the distension in any given instance is difficult of prediction On the whole, however, the longer the duration of the obstruction, the greater is the fluid content Acute obstructions are largely gaseous in character

Source of Fluids Contributing to Distension in Obstruction

The fluids which are dumped normally into the alimentary canal are known to be large in amount From information garnered through a number of sources, Rowntree calculated that, approximately 7,000 cubic centimeters of fluid reached the bowel each day through the activity of glands, which pour their secretions into the upper reaches of the alimentary tube The sources and amounts of these are (1) saliva, 1,500 cubic centimeters, (2) gastric juice, 2,000-3,000 cubic centimeters, (3) bile, 300 500 cubic centimeters, (4) pancreatic juice, 500 800 cubic centimeters, and (5) succus entericus, 3,000 cubic centimeters Dragstedt and his associates (1931) have indicated that this amount may be even greater In an adult of average size, having a plasma volume of 3 500 cubic centimeters Gamble estimates the total daily volume of digestive juices secreted to approximate 8,200 cubic centimeters Adolph (1933) gives the following amounts of fluids recoverable from various glands, organs, and sources in the human body Minimal and liberal estimates of fluids in each instance are given in Table 1

Under conditions of obstruction, these alimentary fluids appear to be increased in amount The Dragstedts (1922) observed an increased excretion of gastric juice, pancreatic juice, and bile following the intravenous injection of obstructed loop content into other dogs They postulated that, owing to increased intravisceral tension in obstruction, abnormal absorption of some of this fluid occurred, which in turn exerted a secretagogue effect on fluid secretion into the bowel Ivy and his associates (1927) noted a similar but less marked effect on the secretion of gastric juice in dogs when the pylorus was obstructed Kim (1933) found that similar increase in the secretion of gastric juice attended the injection of histamine and believes therefore that, the absorption of a histamine like substance in obstruction accounts for the increased fluid secretion The effects of mechanical stimulation alone are not to be overlooked Glinski (1891) found that irritating the mucosa of the intestine with cotton pledgets resulted in an increased watery secretion Herrin and Meek (1933) observed that intestinal distension alone resulted in considerable increase in the secretion

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Chapter I

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Under conditions of obstruction, these alimentary fluids appear to be increased in amount The Dragstedts (1922) observed an increased excretion of gastric juice, pancreatic juice, and bile following the intravenous injection of obstructed loop content into other dogs They postulated that, owing to increased intravisceral tension in obstruction, abnormal absorption of some of this fluid occurred, which in turn exerted a secretagogue effect on fluid secretion into the bowel Ivy and his associates (1927) noted a similar but less marked effect on the secretion of gastric juice in dogs when the pylorus was obstructed Kim (1933) found that similar increase in the secretion of gastric juice attended the injection of histamine and believes therefore that, the absorption of a histamine like substance in obstruction accounts for the increased fluid secretion The effects of mechanical stimulation alone are not to be overlooked Glinski (1891) found that irritating the mucosa of the intestine with cotton pledgets resulted in an increased watery secretion Herrin and Meek (1933) observed that intestinal distension alone resulted in considerable increase in the secretion

tors Kilgore and Bollman (1926) found that, the typical blood chemical changes attending experimental high intestinal obstruction occurred also in gastric and duodenal fistula and that saline solution was of value in averting their occurrence as it was in experimental bowel obstruction These observations were confirmed by Dragstedt and Ellis (1931) and Morton and Pearse (1931)

A number of investigators foremost among whom were Gamble and his associates McIver and Ross (1925), were able to show that the cause of these blood chemical alterations viz, elevation of the nonprotein blood nitrogen decrease in blood chlorides, and an increased combining power of the blood for carbon dioxide, was the loss of fluid and electrolytes from the stomach and upper reaches of the bowel They were also able to show that the reason saline solution proved so effectual in avoiding the occurrence of these changes in the blood as well as in improving the condition of animals with high obstruction was that saline solution serves as a satisfactory substitute for the fluid and sodium and chloride ions lost by vomiting Other variants of sodium chloride when administered with adequate amount of water did not exhibit the virtues of saline solution in this regard Thus the mystery of how saline solution afforded dogs with duodenal or high jejunal obstruction was solved Loss of substances essential to life was the lethal factor, not absorption of a noxious toxin

In low obstructions these chemical alterations in the blood are observed infrequently, undoubtedly because the amount of essential electrolytes and fluid lost by vomiting is less As will be indicated later, the absorption of fluid from the gut in distension is decreased, nevertheless, enough absorption must occur to obviate the occurrence of these changes in the blood It has been demonstrated adequately also in both the experimental animal as well as on patients with clinical obstruction that the liberal administration of saline solution fails to elicit the favorable influence noted when it is given in high obstructions Neither could it be expected reasonably that the administration of saline solution would affect favorably the issue in strangulating obstruction A number of experimental undertakings attest this fact

The Nature of Fluid and Electrolyte Losses in Obstruction

The sources of the body fluids are shown in Fig 3 It is to be noted that intra cellular fluid constitutes the larger fraction When fluid is lost from the body by vomiting as in high obstruction the blood plasma is first drawn upon with ensuant concentration of the plasma The blood, in turn is replenished from the mobile interstitial or intercellular fluid compartment Loss of this fluid gives rise to the clinical evidences of dehydration The intra cellular fluid compartment is spared largely in this withdrawal

The differences in the electrolyte and protein constitution of sea water plasma interstitial and cell fluid are shown in Fig 4 It is to be noted that sodium is the principal cation of both plasma and interstitial fluid, while potassium is the chief cation of cell fluid The chloride ion is the

The Consequences of Fluid and Electrolyte Losses

The brilliant researches of the past two decades have elucidated quite completely the significance of fluid losses, especially in high obstruction. The role of saline solution in prolonging the lives of dogs with experimental high obstruction initiated the examinations which served to elucidate this aspect of the problem. At first it was believed that saline solution was so efficacious in this particular because it detoxified and neutralized a toxin

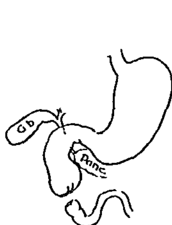


FIG 1—High intestinal obstruction. Until demonstration of the efficacy of water and saline solution in prolonging the lives of dogs with this type of obstruction it was believed that death was due to toxemic absorption. Adequate replacement therapy obviates occurrence of oliguria, azotemia, hypochloremia and alkalosis which attend this type of obstruction. Alkalosis is even more likely to attend pyloric occlusion than duodenal or jejunal obstruction for loss of hydrochloric acid without loss of alkaline bile or pancreatic juice leads more readily to an increase of the bicarbonate ion in the plasma. (Arch Surg 22 658 1931)

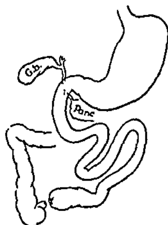


FIG 2—Ileal obstruction. It is this type of obstruction which is responsible largely for continued belief in the toxic absorption theory. The mechanistic conception of the ill effects of obstruction to be developed in this chapter explains quite satisfactorily the sequelae which attend protracted distension of the lower reaches of the obstructed bowel. The old axiom that the high obstructions are the more serious is obsolete. Low obstructions are far more serious. Replacement therapy corrects the situation largely in high obstructions; in low obstructions effective decompression alone can save the situation. (Arch Surg 22 658 1931)

which was otherwise absorbed (Haden and Orr, 1923). It was indicated soon however by a number of studies that the virtue of saline solution lay largely in its capacity to substitute adequately for the fluids lost by vomiting. Foster and Hausler (1924) observed that following temporary administration of saline solution it could be discontinued, and the animals survived just as long. This observation was confirmed by Gatch, Trusler and Ayres (1927) and by Wangensteen and Chunn (1928). Jenkins (1929, 1932), White and Fender (1930), Armour (1931) and Pearse (1931) confirmed this observation of Foster and Hausler in various ways. They found that attending duodenal or high jejunal obstructions if saline solution or the vomitus and other nutritive materials were fed into the jejunal loop beyond the obstruction, long periods of survival were the rule. Wal-

main electrolyte in the acid column for both plasma and interstitial fluid, while phosphate is the principal anion of cell fluid The most conspicuous difference between plasma and inter cellular fluid is the low protein content of the latter

The electrolyte composition of the various gastrointestinal secretions is shown in Fig 5 It will be observed that the total electrolyte composition is, in each instance, approximately the same as in blood plasma In the loss of gastric juice attending the vomiting of pyloric obstruction, it is clear that there will be a larger loss in the chloride ion than in the

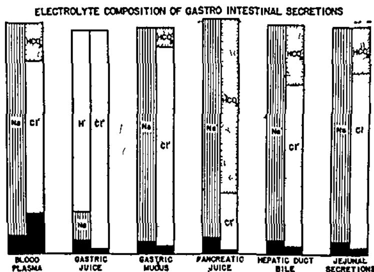


Fig 5—The acid and basic ions of plasma and the gastro intestinal secretions The total electrolyte content is largely the same as in plasma The effect upon the pH from the loss of any of the gastro intestinal secretions can be predicted from a knowledge of the electrolyte pattern of each secretion (see Fig 6) (Gamble J L Harvard Medical School Syllabus 1939)

sodium cation in consequence of which an alkalosis develops with an increase in plasma bicarbonate Accompanying the loss of sodium and chloride ions in the vomitus a lowering of the plasma chlorides occurs and incident to the dehydration oliguria ensues with consequent retention of non protein nitrogen in the blood When large quantities of saline solution are given to repair the loss of fluid and electrolytes, the deficit of sodium is made up before the more extensive loss of chlorides is replenished and the excess sodium is excreted in the urine to re establish the normal balance

From Figs 5 and 6 it is to be deduced that loss of bile and pancreatic juice, will withdraw sodium from the plasma more extensively than the chloride ion Inasmuch as the pH of the intestinal content in the upper reaches of the jejunum is not unlike that of plasma, the withdrawal of base and acid ions attending vomiting of obstruction at this level will be

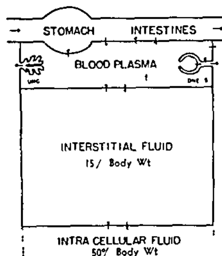


FIG 3—The distribution of fluid in the body Interchange between plasma and the interstitial fluid spaces is free The interstitial fluid compartment reflects directly the status of hydration of the body Dehydration causes anhydremia plethora is accompanied by accumulation of fluid in the interstitial spaces (Gamble J L Harvard Medical School Syllabus 1939)

FIG 4—Composition of plasma interstitial and cell fluid The similarity between plasma and interstitial fluid is striking save for the greater protein content of plasma The Na ion predominates in extracellular fluid the K ion in intracellular fluid (Gamble J L Harvard Medical School Syllabus 1939)

cortical extract is, undoubtedly, a worthwhile expedient in many states, in which capillary permeability is increased When such increased capillary permeability is due to transperitoneal migration of bacteria, administration of cortical extract is probably a futile gesture

Source of Gas Contributing to Distension in Obstruction

The three possible sources of gaseous distension of the obstructed gut are (1) formation of gas as a result of digestive processes, (2) diffusion of blood gases into the intestinal lumen, and (3) passage of swallowed atmospheric air into the intestine The gases commonly present in intestinal meteorism are nitrogen oxygen, carbon dioxide, hydrogen, methane and hydrogen sulfide the proportions being subject to considerable variation

During the ordinary processes of digestion, considerable carbon dioxide may form as a result of an intermixture of acid gastric juice and the alkaline pancreatic and biliary secretions Bunge (1905) states that as much as six liters may arise from this source It is believed also that considerable carbon dioxide may result from the fermentation of sugars and cellulose lower in the bowel Schwartz (1909) decomposed cellulose at 38° Centigrade One hundred grams yielded 19 5 liters of carbon dioxide, 7 5 liters of methane and 4 liters of hydrogen This indicates the enormous amount of gas which may result from the action of bacteria on cellulose The amount of gas formed normally in the gut as a result of the putrefactive action of bacteria on protein is considerably less than that which results from the fermentative action of bacteria on carbohydrates

The walls of the intestine are permeable to gases and an active interchange takes place with the blood gases tending to keep the gases on the two sides of the intestinal mucosa in equilibrium McIver, Redfield and Benedict (1926) observed that when atmospheric air is placed in the cat's stomach carbon dioxide enters from the blood until its concentration equals that in the blood When air containing a high percentage of carbon dioxide is injected into the stomach, carbon dioxide diffuses out of the stomach into the blood Such active replacement occurs, however, in any degree only with readily diffusible gases Nitrogen is absorbed very slowly and exhibits only minimal replacement by carbon dioxide and oxygen McIver, Benedict, and Cline (1926) have calculated the absorptive capacity for the common gases found in the gastro intestinal tract In an hour's time when these gases were introduced into a loop of cat's intestine 25 centimeters in length, they found that 160 cubic centimeters of carbon dioxide was absorbed 69 cubic centimenters of hydrogen sulfide 176 cubic centimeters of oxygen, 7 5 cubic centimeters of hydrogen, 5 cubic centimeters of methane, and 1 25 cubic centimeters of nitrogen After injecting atmospheric air into the lumen of the intestine its volume was observed to diminish during the first and second hours because of absorption of oxygen After the oxygen tension in the bowel had reached that on the other side of the intestinal epithelium, only 4 cubic centimeters dis-

about equal Whereas the effects of dehydration will accompany such obstructions with oliguria and nitrogen retention, alkalosis due to upsets in the ionic balance is not so likely to occur as in pyloric obstruction In diarrhea attending lesions of the ileum and colon, base loss predominates usually over loss of the acid ion with resultant acidosis (Fig 6)

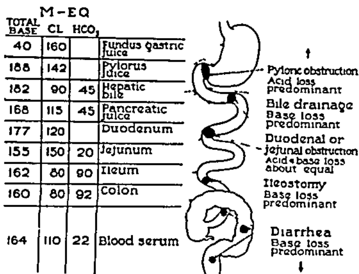


FIG 6—Schematic presentation of the effect of loss of the various gastro intestinal secretions upon the acid base equilibrium of the blood (Coller and Maddock Surg Gynec & Obst 70.345 1940)

The Question of Hyperpotassemia

Reference should be made here to the observations of Cutler and Pijoan (1937) and Scudder and his associates (1937 1938) relating to elevation of the blood potassium levels in obstruction Accompanying fistulas high in the gastrointestinal canal and intestinal obstructions, Scudder and his associates noted an average increase of 100 per cent in the whole blood potassium levels normal values averaging about 25 milligrams per cent They believe this hyperpotassemia may constitute a likely important factor in the lethal issue of obstruction They noted too, that administration of adrenal cortical extract may depress the elevated blood potassium levels

This concept of the importance of potassium as a lethal factor in intestinal obstruction is not shared by many experimental workers Bisgard and his associates (1938) and Greenwood Haist and Taylor (1940) failed to substantiate the contention that potassium was a factor in the cause of death in obstruction In a group of patients with acute obstruction Falconer Osterberg and Bargen (1939) noted a tendency for decrease rather than increase in blood potassium values The writer shares the latter opinion and is not convinced that potassium plays any important role in the lethal issue of intestinal obstruction The administration of adrenal

The Swallowed Air Factor

Inasmuch, however, as these closed loops excluded the greater portion of the juices dumped into the intestinal canal and, in consequence, did not duplicate accurately the conditions present in obstruction, it was believed that more exact information could be gained concerning the role played by swallowed air in the gaseous distension of obstruction by excluding the possibility of swallowing air This was done in the following manner (Wangensteen and Rea, 1939) The cervical esophagus of dogs was transected in the neck, in two stages, and both ends were brought out to

Fig 7—The distension factor in simple obstruction A Effect of esophagostomy on ileal obstruction Large dogs with exclusion of swallowed air by esophagostomy may live a long time and fail to develop distension (See Fig 8 and Table III Wangensteen and Rea Surgery 5 327 1939) B Anastomosis of the severed terminal ileum to the stomach The average survival in 11 dogs with this procedure was 19.9 days—the longest 56 days From the vantage point of the stomach regurgitant vomiting which empties the terminal reaches of the ileum may occur precluding *distension with its damaging effects upon the bowel wall* (Wangensteen and Leven Arch Surg 22 658 1931)

the skin It was learned soon that, the distal end of the esophagus had to be inverted completely to obviate swallowing of air The mechanism of the swallowing of air will be discussed subsequently Dogs in which the cervical esophagus had been thus transected, presenting a fistula of the oral end were fed by a stomach tube through the distal end until the wound in the neck was well healed The dogs prepared best for final operation were fed for a period of about a month s time with liberal quantities of the Scott-Ivy pabulum (See page 203) Then at the same operation the distal end of the cervical esophagus was closed, the gut was

appeared in another five-hour period Fine and his associates (1935, 1936) have elaborated upon this occurrence and have suggested the inhalation of high concentrations of oxygen as a therapeutic measure in gaseous distension in the intestine, subcutaneous emphysema and other states This suggestion will be discussed at greater length later

Kantor (1919) states that gas in the stomach is atmospheric air In a study of postoperative gaseous distension, McIver and his associates found that the gas consisted largely of swallowed air as modified by oxygen replacement by carbon dioxide from the blood They suggested frequent removal of swallowed air, as a measure of value, in relieving postoperative intestinal distension They observed in cats, following the estab-

TABLE II —A GAS AND FLUID ACCUMULATION IN SIMPLE ILEAL OBSTRUCTION

Experiment	Obstruction	Time in days	Gas in cc	Fluid in cc
1	Lower ileum	5	350	350
2	Lower ileum	3	80	80
3	Lower ileum	4	160	180
4	Lower ileum	14	525	590
5	Lower ileum	9	525	900

B CLOSED-LOOP OBSTRUCTION

No of dogs	Site	Av length gut (cm)	Av No hrs	Av No cc gas	Av No cc fluid
20	Lower ileum	57 8	82 1	15 0	91
11	Upper jejunum	32 0	31 0	< 8 5	40

lishment of experimental peritonitis, that when the pylorus was ligated, the stomach filled with gas, but there was no distension of the intestine beyond

In the distension attending mechanical obstructions, however, McIver (1934) states in his monograph on *Intestinal Obstruction* that, decomposition of intestinal contents is probably the most important contributing cause to the distension The occasional amazing results obtained following the employment of suction applied to an inlying duodenal tube in decompressing instances of mechanical obstruction of adhesive origin in which gaseous distension was considerable, suggested that these gaseous distensions were probably also brought about largely by swallowed air, whose transit through the gut was interrupted by the mechanical block Substantial support for this contention was obtained in noting that in a series of twenty five dogs in which simple obstruction was established in the lower ileum, an average accumulation of 328 cubic centimeters of gas and 420 cubic centimeters of fluid was found in the proximal gut of the dogs, whereas in a series of animals with closed intestinal loops, the amounts of fluid and gas collecting in the loops were found to be considerably less as indicated in the accompanying table

obstructed by severing it at the site chosen for obstruction after stripping the tract above of its content These dogs were then given daily 1,500 cubic centimeters of mammalian Ringer's solution subcutaneously A few of the last dogs in the series were transfused a few times with blood from other dogs in an attempt to increase the plasma proteins which were lowered considerably by the long period of starvation To the final dog in the series whose survival was longest vitamins B_1 and C were given subcutaneously each day during the last three weeks of life



Fig 8—The intestines in a dog 57 days after complete ileal obstruction and esophagostomy There was essentially a closed loop of esophagus stomach and small intestine allowing no opportunity for vomiting There was 100 c.c of gas and 125 c.c of fluid in the bowel at autopsy (see Dog 11 Table 3) The hypertrophy of the musculature of the intestinal coils is apparent (Wangensteen and Rea Surgery 5 377 1939)

Results—The results are shown in Table III It is to be noted that the average survival was 35 2 days The longest was 57 days Three dogs survived for 40 days or longer With few exceptions, the amount of gas and fluid found in the gut at autopsy was not great The exclusion of swallowed air permits the closed loop of esophagus, stomach and small intestine to reabsorb the greater portion of the digestive juices dumped into the gut In Fig 8 it is apparent that the bowel wall is thickened The residual content of the obstructed bowel was surprisingly small The longest period of survival in the controls was considerably shorter averaging about 5 days

How Is Gas Swallowed?

It has been stated already that when the cervical esophagus of dogs was transected as long as the distal end remained open considerable air was still swallowed This would indicate that the swallowing of air is connected intimately with respiration and would suggest that the negative intrathoracic pressure is largely responsible for its occurrence

A somewhat similar situation exists in the instance of a baby nursing a bottle He applies suction to the nipple and a slight negative pressure is established in the bottle, which in turn causes the inrush of air and displaces the milk The baby does not actually apply enough suction to draw the milk out If the bottle were a closed system and the ingress of air was prevented the exertion of a thousand pounds negative pressure per square inch would not bring out more than a few drops of milk Unless the walls of the glass bottle were actually sucked in by the force applied the milk could not be evacuated unless the entry of air was allowed

TABLE III ESOPHAGOSTOMY AND ILEAL OBSTRUCTION (WANGENSTEEN & REA SURGERY 5 327 1939)

Operation	Dog No	Initial Weight (kg)	Saline Solution (c c)	Survival in Days	Gas (c c)	Fluid (c c)	Weight at Death (kg)	Remarks
Esophagostomy + feeding for 1 month then closure of the distal esophageal opening and terminal ileal obstruction + saline solution	1	24 0	1 500	19	100	150	16 5	Dogs 1–7 showed no distention of the gut except for segment 15 to 20 cm proximal to *ileal obstruction*
	2	20 0	1 500	20	150	50	16 0	
	3	17 5	1 500	32	0	100	12 0	
	4	26 0	1 500	40	* 50	50	15 2	Dog 4 received 2 transfusions of citrated blood 300 c c each Total plasma protein *just before death* 4 5 *gm* %
	5	15 9	1 500	29	0	350	12 5	
	6	17 0	1 500	45	50	60	11 5	
	7	18 5	1 500	34	0	90	10 0	
	8	18 0	1 500	33	175	150	13 5	Slight distention
	9	15 0	1 500	33	600	800	9 5	Died with a volvulus gut markedly distended
	10	20 0	1 500	45	1 000	350	14 5	Stomach and jejunum are contracted received 4 transfusions of citrated blood 300 c c each after ileal obstruction
	11	18 3	1 500	57	100	125	12 5	Ileum was distended and contained 500 gm of semisolid fecal material this dog received a total of 5 transfusions of citrated blood 300 c c each after the ileal obstruction just before the animal was sacrificed plasma protein 4 4 gm % plasma chlorides 676 mg % and nonprotein nitrogen 60 6 mg %
Average survival				35 2				

* Too small to be measured accurately

directly from the intestine into sample tubes Since the unoperated clinical cases were being decompressed by continuous duodenal suction, the gas sample was obtained by connecting the inlet tube directly to the suction apparatus by a three way stop cock In order to exclude the factor of atmospheric air in the duodenal tube, samples were collected after the suction had been in operation for a while

Results

The results are indicated in the accompanying Tables IV to XI In thirteen dogs, the terminal ileum was severed and the ends inverted The survival period, the amount of fluid and gaseous content obtained in each instance together with the gas analyses appear in Table IV

In Table V are indicated the results observed in a group of 6 dogs in which a preliminary cervical fistula for diversion of swallowed air had been established, followed by obstruction of the terminal ileum

Similar determinations were made in a group with closed loop obstructions of the small intestine, in which the continuity of the remaining gut was re established The results of the analysis appear in Table VI

Determinations were made upon gas accumulating in the pelvic colon of two groups of dogs in one, simple obstruction was established by severing and inverting the ends of the gut, in the other, a preliminary *esophagostomy to obviate the swallowing of air was done In the latter* group, it is quite apparent that the exclusion of swallowed air does not reduce so successfully the amount of gas in the bowel as it did in obstruction of the small bowel when a similar procedure was done

TABLE IV —QUANTITATIVE ANALYSIS OF GASEOUS ACCUMULATIONS IN SIMPLE ILEAL OBSTRUCTION

Dog No	Wt lb	Duration days	Fluid content c c	Gaseous content							Volatile basic group %
				Amount c c	CO_2 %	O_2 %	N_2 %	CH_4 %	H_2 %	H_2S %	
1	55	2	150	100	—	—	—	—	—	—	—
2	50	2	—	—	4 7	10 0	65 0	0	0	4 3	
3	42	3	300	150	6 2	1 5	71 0	0	0	7 9	
4	48	3	290	200	12 7	1 1	60 0	0	0	14 0	
5	42	3	150	220	12 0	0 7	70 0	0	0	2 0	
6	46	3	220	290	9 3	1 0	74 0	0	0	0 9	
7	44	3	235	320	9 1	0 5	70 0	0	0	4 3	
8	55	3	1196	325	13 1	1 8	73 6	0	0	9 4	2 0
9	36	5	400	200	11 5	0 9	79 4	0	0	6 5	1 5
10	34	7	200	300	8 8	2 1	66 0	0	0	13 2	8 7
11	48	3	210	225	24 2	0 3	53 0	0	3	17 9	4 2
12	32	6	750	250							
13	43	3	420	430	15 0	1 5	23 0	0	5	45 1	
Average			373	235							
Minimum			150	100							
Maximum			1196	430							

Dead

The order of magnitude of the force which causes the suction of air down the esophagus is not great, but when it is realized that this same small negative pressure counteracts the elasticity of the lung, which tends to collapse it, the effect of a slightly superior force can be understood A pressure of 760 millimeters of mercury is exerted on the external chest wall and is counterbalanced by an equal force coming down the trachea in the inspired air A differential pressure of a few millimeters of mercury serves to keep the lung expanded, a force representing an advantage of only ½ to 1 per cent of the major forces acting

What circumstances other than negative intrapleural pressure favor the swallowing of air are not apparent Whether patients after abdominal operations swallow more air than normally remains to be established The action of the superior constrictor muscle of the esophagus probably normally interferes with the passage of air down into the stomach When a nasal catheter is passed into the pharynx for the insufflation of oxygen into the lungs, it is observed that when the distal end of the catheter lies at the lower end of the oropharynx, relatively small quantities of oxygen go into the stomach, when, however, the end of the catheter is passed somewhat beyond the oropharynx, practically all the oxygen may pass into the stomach

Qualitative Analysis of Gas Accumulating in the Bowel in Obstruction

McIver and his associates (1926) have made determinations upon the gas aspirated from the stomach after operations, which they found to be largely atmospheric air with some displacement of oxygen by carbon dioxide No determinations have been made in instances of mechanical obstruction With the object in mind of determining in so far as possible the source of gas accumulating in the bowel, qualitative analyses were made by Hibbard and Wangensteen (1934) in various types of experimental obstruction Analyses have been made also upon gas aspirated with a duodenal tube in instances of mechanical obstruction as well as upon samples obtained at operation

Method—The United States Bureau of Mines apparatus was employed in making the analyses and the aid of a qualified gas chemist enlisted Carbon dioxide was determined by absorption in 30 per cent potassium hydroxide, oxygen in alkaline pyrogallol, hydrogen sulfide in arsenous chloride, and the volatile basic group was absorbed in a known acid and titrated with a known alkali Hydrogen and the saturated hydrocarbons were determined by the explosive method

In the animal experiments samples of gas were drawn over mercury into specially made gas tubes while the animals were under ether The intestine was ligated over the tip of the inlet tube, after the mercury had been forced to the top By lowering the leveling bottle so as to produce gentle suction, with the aid of a simultaneous stripping process applied to the intestine, in the direction of the inlet tube, the entire volume of gas was drawn into the gas tube By this maneuver the dead space as a source of error was eliminated satisfactorily

In the clinical case operated upon the gas was drawn over mercury

TABLE VIII —THE VALUE OF THE GASEOUS CONTENT OF BOWEL AFTER SIGMOID OBSTRUCTION WITH ESOPHAGOSTOMY

Dog No	Wt lb	Duration days	Fluid content c c	Gaseous content						
				Amount c c	CO_2 %	O_2 %	N_2 %	CH_4 %	H_2 %	H_2S %
1	44	3	150	16,	10 9	1 4	63 2	—	12 4	10 1
2	40	3	12,	450	18 4	0 5	58 8	0 6	4 2	12 6
3	30	3	220	310	12 2	1 4	73 4	2 8	1 6	8 6

TABLE IX —COMPOSITION OF GAS IN CLINICAL CASES OF SMALL BOWEL DISTENSION (MAN)

No	Diagnosis	X ray reading	Method of obtaining gas	Composition of gas						Volatile base group— %
				N %	O %	CO %	H %	CH %	H S %	
1	Mechanical obstruction of ileum	Marked distension of small bowel	Aspiration at operation	60 0	3 0	9 4	0	0	14 0	13 6
2	Mechanical obstruction of ileum	Marked distension of small bowel	Nasal suction	70 0	10 0	9 0	0	0	5 8	5 2
3	Mechanical obstruct n	Distension of the small bowel	Aspiration at operation	9 0	9	8 1	0	0	10 0	—

TABLE X —NATURE OF GAS IN CLINICAL CASES OF INHIBITION ILEUS (Paralytic)

No	Diagnosis	X ray findings	Method of obtaining gas	Composition of gas					
				N %	O %	CO %	H %	CH %	H S %
1	Diffuse peritonitis	Distension of small and large bowel	Aspiration half hour postmortem	74 2	9 2	7 7	1 2	—	7 7
2	Diffuse peritonitis	Distension of small and large bowel	Nasal suction	71 6	4 4	10 6	6 6	—	6 2
3	Diffuse peritonitis	Distension of small and large bowel	Nasal suction	64 6	8 0	11 8	6 3	1 0	8 4
4	Diffuse peritonitis	Distension of small and large bowel	Nasal suction	80 4	10 0	5 6	0 3	0	3 7

Determinations were made in three cases of mechanical obstruction of the small intestine four cases of peritonitis with established distension, and in four cases of mechanical obstruction of the colon In two of this

TABLE V—QUANTITATIVE ANALYSIS OF GASEOUS ACCUMULATIONS IN SIMPLE ILEAL OBSTRUCTION WITH ESOPHAGOSTOMY

Dog No	Wt lb	Duration days	Fluid content c c	Gaseous content						
				Amount c c	CO_2 %	O_2 %	N_2 %	CH_4 %	H_2 %	H_2 %
1	36	3	250	110	12 8	1 1	76 3	0	0	9 8
2	34	3	240	140	9 0	3 2	85 0	0	0	3 1
3	41	3	300	40	9 5	0 4	73 4	0	0 2	8 0
4	43	3	250	100	12 0	5 7	76 2	0	0	6 1
5	28	3	225	160	—	—	—	—	—	—
6	45	3	100	60	12 8	0 9	71 6	0 3	0 4	14 4
Average *			227	101						
Minimum			100	40						
Maximum			300	160						

TABLE VI—THE GASEOUS CONTENT OF CLOSED LOOP OBSTRUCTION OF SMALL INTESTINE

Dog No	Wt lb	Duration days	Fluid content c c	Gaseous content							Volatile basic group %
				Amount c c	CO_2 %	O_2 %	N_2 %	CH_4 %	H_2 %	H_2S %	
1	36	2	60	90	—	—	—	—	—	—	—
2	42	2	150	70	4 5	12 3	87	—	—	—	—
3	40	3	225	83	8 3	2 4	74	—	—	12 8	1 6
4	42	3	1050	40	10 0	4 0	—	—	—	3 0	trace
5	30	5	130	10	—	—	—	—	—	—	—
6	44	8	200	100	—	—	—	—	—	—	—
7	38	3 dead	600	40	5 1	2 8	51	0	0	15 3	
8	46	3	—	—	18 0	1 0	11	0 1	3 2	62 7	
9	52	dead									
9	52	3 dead	—	—	13 0	1 8	37	0	2 3	24 2	3 2
10	26	4 dead	350	20	—	—	—	—	—	—	—

TABLE VII—VALUE OF GASEOUS CONTENT OF BOWEL AFTER OBSTRUCTION OF SIGMOID COLON

Dog No	Wt lb	Duration days	Fluid content c c	Gaseous content						
				Amount c c	CO_2 %	O_2 %	N_2 %	CH_4 %	H_2 %	H_2S %
1	50	8	650	385	6 5	1 2	80 0	2 6	0	6 7
2	47	3	100	215	10 8	1 4	80 6	1 6	0	5 6
3	39	3	110	375	13 0	0 8	80 1	—	1	4 1

TABLE VIII.—THE VALUE OF THE GASEOUS CONTENT OF BOWEL AFTER SIGMOID OBSTRUCTION WITH ESOPHAGOSTOMY

Dog No	Wt lb	Duration days	Fluid content c c	Gaseous content: Amount c c	CO_2 %	O_2 %	N_2 %	CH_4 %	H_2 %	H_2S %
1	44	3	150	165	10 9	1 4	63 2	—	12 4	10 1
2	10	3	125	450	18 4	0 5	58 8	0 6	4 2	12 6
3	30	3	220	310	12 2	1 4	73 4	2 8	1 6	8 6

TABLE IX.—COMPOSITION OF GAS IN CLINICAL CASES OF SMALL BOWEL DISTENSION (MAN)

No	Diagnosis	X ray readings	Method of obtaining gas	Composition of gas: N %	O %	CO %	H %	CH %	H S %	Volatile basic group %
1	Mechanical obstruction of ileum	Marked distension of small bowel	Aspiration at operation	60 0	3 0	9 4	0	0	14 0	13 6
	Mechanical obstruction of ileum	Marked distension of small bowel	Nasal suction	70 0	10 0	9 0	0	0	5 8	5 2
3	Mechanical obstruction	Distension of the small bowel	Aspiration at operation	79 0	2 9	8 1	0	0	10 0	—

TABLE X.—NATURE OF GAS IN CLINICAL CASES OF INHIBITION ILEUS (Paralytic)

No	Diagnosis	X ray findings	Method of obtaining gas	Composition of gas: N %	O %	CO %	H %	CH %	H S %
1	Diffuse peritonitis	*Distension of small and large bowel*	*Aspiration half hour postmortem*	*4 2*	*9*	*7 7*	*1 2*	—	*7 7*
2	Diffuse peritonitis	Distension of small and large bowel	*Nasal suction*	*72 6*	*4 4*	*10 6*	*6 6*	—	*6 2*
3	Diffuse peritonitis	Distension of small and large bowel	Nasal suction	64 6	8 0	*11 8*	*6 3*	*1 0*	*8 4*
4	Diffuse peritonitis	Distension of small and large bowel	Nasal suction	80 4	10 0	5 6	0 3	0	3

Determinations were made in three cases of mechanical obstruction of the small intestine, four cases of peritonitis with established distension and in four cases of mechanical obstruction of the colon. In two of this

latter group, the gas was obtained from the upper reaches of the gastro-intestinal tract by suction applied to a duodenal tube, in the two others, by aspiration after the establishment of colostomy The results are indicated in Tables IX, X, and XI

Comment

In the striking difference, in the greater amount of gas present in the terminal ileal obstructions, as contrasted with the amount present where the same procedure was done accompanied by a fistula of the cervical esophagus, as well as in closed loops of the small intestine, the significance of swallowed increments of air in the genesis of intestinal distension is apparent

The gas present in the closed loops and in those instances in which the swallowed air factor had been excluded, must have arisen by fermentation

TABLE XI —THE GASEOUS CONTENT IN CLINICAL CASES OF LARGE BOWEL OBSTRUCTION

No	Diagnosis	X ray findings	Method of obtaining gas	Composition of gas					
				N %	O %	CO %	H %	CH %	H S %
1	Carcinoma of rectum	Distension of the large bowel	Nasal suction	70 4	17 0	3 4	0 8	0	? 8
2	Carcinoma of the splenic flexure	Distension of the large bowel	Nasal suction	77 2	13 2	7 2	0	0	2 4
3	Carcinoma of the rectum	Distension of the large bowel	Aspiration of colostomy loop	74 0	1 ?	8 4	4 0	2 6	10 2
4	Carcinoma of the rectum	Distension of the large bowel	Aspiration of colostomy loop	69 0	3 4	11 0	8 0	—	8 2

or putrefaction in the gut or must have been brought there from the blood stream The high per cent of nitrogen in the gas of these cases was at first somewhat of a surprise, but when the high tension of the small amount of gaseous nitrogen (570 millimeters of mercury) in the blood is recalled, the diffusion of nitrogen into the gut under the circumstances mentioned is understandable As a matter of fact, that could be its only source, for free nitrogen gas is not formed in the intestinal canal The nitrogen has undoubtedly displaced gas such as carbon dioxide or hydrogen sulphide, which diffuse readily through the bowel wall It was observed as the obstructions progressed in duration that the amount of carbon dioxide hydrogen sulphide, and volatile basic group of gases (ammonia, methyl amine, and tertiary amines) increased (Hibbard 1936) The oxygen present was always low

In animals dead when the gas determinations were made, the amount of hydrogen sulphide present was greatly increased as is indicated in Table VI The increase in hydrogen sulphide, in these instances, as well as in the terminal obstructions where this figure was also high is probably due

to an increase in protein putrefaction The amounts of hydrogen sulphide as well as ammonia present in the gut, either as gas or in solution, were found to be non toxic when injected into closed intestinal loops as well as into the intestinal canals of normal dogs As is well known these gases are extremely toxic, but in the amounts present in obstruction they are detoxified apparently in the process of passing through the bowel wall

It may be concluded then that, about 68 per cent of gas in the intestine in obstruction has its origin in swallowed air, 32 per cent forms within the body Of this latter amount, as determined by exclusion of the swallowed air factor in the closed loop series and the high nitrogen content about 70 per cent originated by diffusion of blood gases and especially nitrogen into the bowel lumen, the remaining 30 per cent originated within the obstructed loop

B THE MANIFESTATIONS OF DISTENSION UPON THE BOWEL WALL

How the Manner of Obstruction Influences the Effects of Obstruction

In order to establish a satisfactory basis for the discussion to follow, it is necessary to relate a few facts which have come largely to be recognized generally concerning the influence of the manner and the site upon the effects of obstruction There are essentially two varieties of obstruction (1) simple obstruction in which the continuity of the bowel alone is blocked, and (2) strangulating obstructions, which exhibit in addition to interruption of intestinal continuity, compromise of the blood supply The latter group because of the arrest of venous outflow from the bowel wall manifests more quickly than do instances of simple obstruction evidences of damage to the bowel wall Another factor the loss of blood is introduced also and will be described in more detail later Distension *per se* may imitate at least in part some of the effects of strangulating types of obstruction

Influence of the Site of Obstruction Upon the Effects of Distension

In man observation indicates and in the dog experiment affirms the impression that the site of the obstruction has an important bearing upon the effects of obstruction A dog with a complete simple obstruction of the duodenum below the entrance of the pancreatic ducts may with satisfactory replacement by saline solution of the fluids and electrolytes lost by vomiting be kept alive for three to four weeks without disturbance of mineral or nitrogen metabolism If saline solution were not administered death would occur in three or four days with characteristic metabolic disturbances namely oliguria and finally anuria with consequent azotemia, hypochloremia and alkalosis Similarly a patient with obstruction of the efferent loop of the jejunum, leading away from the stomach after gastro jejunostomy or gastric resection may with the administration of an adequate amount of saline solution tolerate without serious threat to life the loss of these digestive juices for a comparatively long period of time (14 to 21 days)

In low ileal obstruction in which vomiting fails to empty the lower

*latter group, the gas was obtained from the upper reaches of the gastro-*intestinal tract by suction applied to a duodenal tube, in the two others, by aspiration after the establishment of colostomy The results are indicated in Tables IX, X, and XI

Comment

In the striking difference, in the greater amount of gas present in the terminal ileal obstructions, as contrasted with the amount present where the same procedure was done accompanied by a fistula of the cervical *esophagus, as well as in closed loops of the small intestine, the significance* of swallowed increments of air in the genesis of intestinal distension is apparent

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In animals dead when the gas determinations were made, the amount of hydrogen sulphide present was greatly increased as is indicated in Table VI The increase in hydrogen sulphide, in these instances, as well as in the terminal obstructions where this figure was also high is probably due

Length—Whereas, the anatomical length of the intestine is considerable, the physiologic length, as van der Reise and Schembra (1926) have shown, is considerably less In instances of fistula in the terminal ileum, a catheter of 6 to 9 feet in length was found to negotiate the entire length of the small bowel The bowel reefs itself upon the tube, making it possible for a much shorter tube to extend through a considerably greater length of bowel A Miller-Abbott tube, which is 11 feet in length, may pass readily throughout the entire length of the alimentary canal

When the bowel is distended, contraction of the longitudinal muscle results frequently in shortening of the bowel length In order to measure the extent of this process in obstruction, ligatures, which could be subsequently readily identified were measured off at 12 inch intervals along the mesenteric border above the site of obstruction

Sperling (1938) observed quite uniform shortening of the bowel attending acute obstructions Placing lead shot along the bowel wall, Bellis (1939) was unable to confirm in similar experiments carried out subsequently that, shortening attended obstruction uniformly In chronic obstructions, lengthening of the bowel is not unusual

Weight—A large number of determinations were made (Sperling and Wangensteen 1935) of the weight of consecutive 12 inch lengths of the empty small bowel in a number of dogs There was no direct correlation between the weight of the dog and the bowel It was observed that the bowel decreased in weight from the duodenum toward the ileum When the terminal ileum was obstructed however, a reversal occurred, such that the empty segments near the obstruction were the heavier

When correction is not made for the shortening which attends acute obstruction frequently (20 to 33 per cent) the apparent increase in weight of the obstructed bowel is great (114 per cent) After allowance has been taken of this factor however the increase in weight though much less is still real (34 per cent)

Strength—The strength of the normal bowel wall of the dog has been examined by Cutting (1928) and again by Morton (1929) They determined the resistance offered by different segments of the gut to increases of intraluminal pressure of such a grade as to cause bursting of the wall Cutting estimated the breaking point of the gut to be between 1 000 and 1 500 millimeters of mercury Morton found that the bowel resisted pressures of 500 millimeters of mercury usually before the gut wall burst

Similar determinations (twenty four in number) were made on normal bowels of animals recently killed and upon the gut where obstruction had previously been established (in twenty instances) (Sperling and Wangensteen 1935)

The bursting strength of the normal ileum of the dog was found to lie between 300 and 1 000 millimeters of mercury The bursting pressures for jejunal segments fell within the same limits, as one would expect however because of the larger lumen of the more oral segments they ruptured on the whole at lower pressures than did the narrower ileal segments Tearing or splitting of the serosa occurred at slightly lower levels of pressure

reaches of the distended bowel, the factor of distension operates to complicate the picture In the dog, saline solution fails to prolong the lives of dogs with ileal obstructions beyond the 7 to 9 day period, which dogs will survive ileal obstruction, if untreated And the upsets in mineral and nitrogen metabolism, related above, are frequently not in evidence

In man, the ileocecal valve and sphincter play a singular role in influencing the character of the symptoms as well as the effects of obstruction of the colon In colonic obstruction the contents of the upper reaches of the gastrointestinal canal are permitted free entry to the colon, but because of the check valve nature of the ileocecal juncture, regurgitation from the distended colon into the terminal reaches of the small intestine does not occur frequently Inasmuch as gastric retention is not present, vomiting is not a prominent feature and may be absent altogether Regurgitant vomiting of a brownish feculent material is synonymous with obstruction of the lower reaches of the small intestine In colonic obstructions, therefore, distension with development of high intraluminal pressures is the rule Occasionally, one of the lips of the ileocecal valve is short or deficient (the lower usually) under which circumstance regurgitation into the ileum may accompany colonic obstruction

Reference has been made already to the effects of obstruction to the efferent jejunal loop after the establishment of a gastro jejunal anastomosis When obstruction occurs at the gastro jejunal stoma to the afferent loop, after gastric resection in the Billroth II type of operative procedure, or even after gastro jejunostomy performed for obstruction at the pylorus, a closed short loop type of obstruction develops with ensuant severe damage to the bowel proximal to the stoma Death from hyperthermia occurs usually within 30 to 48 hours after operation and the cause of death is ascribed frequently to pneumonia or pulmonary atelectasis This complication of gastric resection has been probably an important item in the mortality factor of gastric resection Avoidance of distension of the afferent loop of a gastro jejunal anastomosis by the placement of an in dwelling duodenal tube into the loop, at the time of operation will serve to eliminate the serious threat of this complication It is to be remembered in this connection that Dragstedt, Lang and Millet (1929) pointed out that blood flow is arrested in the duodenum by intraluminal pressures which fail to obstruct blood flow to the ileum or colon (see page 231)

The effects of distension are largely manifest upon the bowel wall High grade distensions may, of course, embarrass respiration and heart action through pressure upon the diaphragm This influence of distension, moreover, is undoubtedly inconsiderable as contrasted with the far more serious portent of long continued distension upon the wall of the bowel

The effect of distension upon the bowel is best assayed in terms of increased intraluminal tension In order to measure the influence of increased pressure upon the blood supply, the absorption from and the permeability of the bowel wall, it is necessary to know the grades of pressure present in bowel obstruction The effects of obstruction upon the length, weight, and strength of the bowel will be first briefly related

infrequently anatomical evidence of the effects of considerable distension, these appear to be most unusual in the small bowel

With these clinical observations in mind, efforts were made to determine the pressure in the obstructed small intestine and colon of both dog and man A number of observations have been possible upon patients who have had an organic obstruction in the pelvic colon due to malignancy, at the time that colostomy was done, with others, an opportunity was afforded to measure the intra colonic pressure in instances where colostomy was performed before subsequent excision for carcinoma of the rectum Pressures were determined in patients with obstruction of the small bowel directly following the placement of an enterostomy catheter into the bowel In patients with acute obstruction of the colon, similar determinations were obtained by inserting a needle into the bowel after closure of the skin In the instances where colostomy was done preliminary to subsequent operation upon the rectum, pressures were obtained just before opening the colostomy

Intra enteric Pressure in the Obstructed Small Bowel

In dogs the intra enteric pressure was determined by Sperling, Paine and Wangensteen (1935) in nineteen animals in which simple low ileal obstructions had been established Sustained pressure readings ranging from 4 to 19 centimeters of water were noted Active peristalsis of the gut was observed invariably even after seven days of obstruction The average sustained pressure in this group was somewhat more than 9 centimeters, the resultant pressures were as follows

In one obstruction of 24 hours' duration the sustained pressure was 8 centimeters of water in four obstructions of 48 hours' standing variations in sustained intraluminal pressure from 4 to 12 centimeters were found, in two of 72 hours' duration, pressures of 10 and 12 centimeters were observed, in ten animals in which the duration of obstruction was 96 hours the sustained intra enteric pressures varied between 8 and 14 centimeters of water and in two obstructions of 168 hours' standing pressures of 12 and 19 centimeters were found

On six additional dogs seventeen measurements of intra enteric pressure were made at varying intervals after the establishment of obstruction in the following manner A loop of gut of three to four inches in length was brought up on the abdominal wall and the adjacent skin was mobilized to cover it When this 'satchel like handle" was well healed complete obstruction was accomplished by inverting the ends of the severed terminal ileum In a few instances, two such subcutaneous loops were made in the same dog The usual sustained intra enteric pressure found varied between 6 and 8 centimeters of water The highest reading obtained was 17 centimeters

After placing an enterostomy tube in the gut in four cases of clinical obstruction of the small bowel of mechanical origin, of 48 to 96 hours duration pressures were made as described above The sustained pressures varied between 4 and 14 centimeters of water, with peristaltic activity, occasional pressures of 20 or 30 centimeters were noted

In the obstructed series, the reverse was found to be true The heavier segments near the site of obstruction burst more readily than did the more oral segments, further removed from the site of obstruction The breaking strength was found to lie between 180 and 760 millimeters of mercury

Breaking Strength of Small and Large Intestine in Man—The breaking strength of segments of the human bowel, removed at operation, has been determined by Hay (1940) In a series of 10 patients from whom segments of intestine were removed during the removal of tumors, the bursting strength was noted to vary between 80 and 260 mm Hg of mercury The usual range of values for the small intestine varied between 140 and 260 mm Hg Only two colons, in this group, were available for determination of the breaking strength In both instances, the cecum ruptured at 80 mm Hg pressure, rupture of the ileum in one of these occurred at 260 mm and, in the other, at 230 mm Hg pressure

It would appear that the breaking strength is really a resolution of the diameter of the lumen and the thickness of the bowel wall It was somewhat of a surprise to note at what relatively low pressures the cecum burst However, when one recollects how distensible the cecum is, rupture of the cecum or other segments of the colon, at relatively low pressures is understandable

The striking difference in the breaking strength of the bowel of dog and man, under the influence of increased intraluminal pressure is to be borne in mind In neither of the two patients cited above, in which segments of colon were available for examination, was obstruction present That obstruction lowers the breaking strength of the bowel wall, notably, has been pointed out, already, with reference to the dog

The Intra-enteric Pressure in Bowel Obstruction

Owings, McIntosh, Stone, and Weinberg (1928) have determined experimentally on normal dogs the sustained intraluminal pressure to be 2 to 4 centimeters of water pressure In simple ileal obstruction, a sustained pressure of 8 centimeters of water was found, and during activity of the bowel, pressures of 30 to 60 centimeters of water were obtained In closed intestinal loops, Owings and his associates observed intraluminal pressures as high as 70 centimeters of water In jejunal closed loops of dogs, Burget and his associates (1930) observed pressures varying from 30 to 60 centimeters of water Morton and Sullivan (1930) compared closed jejunal loops with similar ones in the ileum The intra enteric pressure of the jejunal loops (52 centimeters of water) was seven times that developed in the ileal (8 centimeters) This difference in the accumulation of intraenteric pressures, they concluded rightfully, was due to the greater secretion in the jejunal loops A greater tendency toward perforation was observed also in the closed jejunal loops

Observation of the effects of distension upon the bowels of patients with obstruction suggests a behavior different in the small bowel from that of the colon Whereas the colon (and usually the cecum) exhibits not

and sphincter in obstruction of the colon Saeltzer and Rhodes (1935) have described instances too of diastasic perforation of the cecum, occasioned by obstruction of the colon Though the possibility of this occurrence was described by Heschl long ago, it is only within the past decade that surgeons have become alive to its importance

Whereas the roentgenologist can effect entry ordinarily of the small intestine with barium administered as an enema, he employs usually an elevation of gravity pressure of more than three feet (90 centimeters)

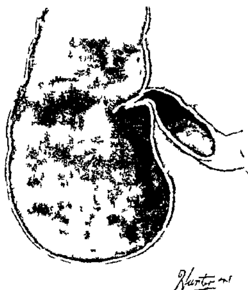


FIG 9—Check valve mechanism of lips of ileocecal valve and sphincter Increasing tension in the cecum approximates the lips of the ileocecal valve indicating how a closed loop obstruction develops with colonic occlusion Deficiency of one of the lips would permit regurgitation into the ileum

and in addition employs manipulation of the abdominal wall It will be recalled that the greatest pressure measured in the five cases of clinical obstruction of the colon was 52 centimeters of water and that such pressures exceed 25 centimeters of water rarely Inasmuch as barium is considerably heavier than water it is immediately apparent that the roentgenologist employs pressures far in excess of those which develop spontaneously in the colon Furthermore, undoubtedly there is also a vast difference between gradual accumulation of pressure in the colon in its effect upon the ileocolic sphincter and valve and that observed when the colon is distended rapidly with an enema

The Intra-colonic Pressure in Obstruction

Pressures were obtained at operation when colostomy was performed for relief of distension in five cases of acute colonic obstruction due to malignancy The sustained pressures varied in these five cases between 12 and 52 centimeters of water, in four of the cases pressures above 23 centimeters of water were recorded, much higher figures than were observed in the small bowel The duration of obstruction in these cases varied between three and eight days Determination of the intra colonic pressure, in obstructed colons, *is made regularly now, in the manner indicated in Fig* 30, on completion of transverse colostomy aimed at relief of the obstruction Intraluminal pressures of 10 to 25 centimeters of water pressure are the usual findings

In twelve other cases in which colostomy was done preliminary to excision or other operation upon the rectum, pressures were obtained by inserting a needle into the exteriorized bowel Pressures varying between 10 and 26 centimeters of water were obtained In all of the cases suction had been applied constantly to an inlying duodenal tube following the colostomy Consequently opportunity was not afforded for building up as great pressures as would have occurred otherwise Nevertheless the occurrence of intraluminal pressures of this grade in the colon, despite the exertion of suction in the upper reaches of the intestinal canal, indicates the futility of duodenal intubation in influencing the established distension in cases presenting acute obstruction of the colon

The Influence of the Ileocecal Sphincter and Valve

A number of factors indicate that the ileocecal sphincter and valve may convert a simple obstruction of the colon into a closed loop obstruction In instances of acute obstruction of the colon operated upon despite enormous distension of the colon the terminal ileum has frequently been observed not to be distended Not infrequently in neglected cases of acute obstruction of the colon, the bowel may perforate despite absence of vomiting These perforations are usually in the cecum, the portion of the bowel having the greatest diameter and consequently most dilatable Even *though the intraluminal pressure is the same in the cecum as it is in the* narrower descending colon the stress on the bowel, borne by the walls of the cecum, is as much greater than that of the descending colon as is its greater volume

Heschl (1880) was the first to call attention to the importance of the ileocecal valve and sphincter in causing diastasic perforation of the cecum in the presence of colonic obstruction Later Anschuetz (1902) reiterated the importance of its occurrence Shimodaira of Kocher's clinic (1911) collected forty eight cases of perforation of the bowel attending obstruction of the colon The majority were in the cecum This occurrence was first noted in this clinic in 1931 and in 1934 the writer was convinced *that the symptoms of large and small bowel obstruction could be dif*ferentiated frequently on the basis of the behavior of the ileocecal valve

sponsible for the migration In this connection, it may be said that reversals of the intestine in the dog are not tolerated well and such animals die of obstruction (Mall 1896, Prutz and Ellinger 1902, 1904) Enderlen and Hess (1901) noted that reversal of the intestine could be tolerated The writer observed too, a number of years ago, that if shorter lengths were reversed and the operation carried out in stages, surprisingly long segments of the small intestine in the dog could be reversed The writer has also made an antiperistaltic anastomosis between a loop of jejunum and the stomach in man, transplanting the jejunal loop beneath the skin for feeding, without observing any notable difference in the behavior of such a loop, and one in which the normal intestinal gradient is toward the stomach These considerations, as well as ability of the patient to empty, at least partially through the agency of vomiting, a distended loop of bowel suggests that, reversed contractile activity may occur in the intestine

Effects of Increased Intra enteric Pressure Upon the Bloodflow to the Bowel

It is apparent that increases in intraluminal pressure in instances of bowel obstruction may affect unfavorably the blood supply of the gut van Zwalenburg (1907) studied the effect of distension upon bloodflow through the bowel wall of the dog by means of an electric bulb within the lumen He observed capillary stasis at 30 millimeters of mercury pressure, venous stasis at 60 millimeters, partial arterial arrest at 90 millimeters, and finally complete arrest of the circulation at 130 millimeters Gatch, Trusler, and Ayres (1927) cannulated the mesenteric veins returning from closed loops and measured the minute volume flow under experimentally increased intra enteric pressure For each increment of increased intraluminal pressure a corresponding decrease in bloodflow occurred Dragstedt, Lang, and Millet (1929) made similar determinations at different levels of the intestinal canal and found that the circulation of the duodenum was more profoundly affected than any other portion of the bowel by increased intra enteric pressure

The pressures employed by these investigators, however, were far in excess of the sustained pressures observed in experimental or clinical obstructions of the small intestine Gatch and his associates observed, when no resistance was offered to the return flow of blood from the mesenteric vein of an isolated intestinal loop, that an average return of 18 cubic centimeters per minute was noted in six dogs When the intraluminal tension was raised to 25 millimeters of mercury pressure, an average return of 17 cubic centimeters per minute was observed at 50 millimeters pressure, the return flow was 13 centimeters per minute, and at 75 millimeters, it was still 10 1 centimeters Even at 200 millimeters pressure, an average return flow of 3 centimeters per minute was observed Inasmuch as this pressure exceeds considerably the arterial blood pressure of the dog, it is apparent, as the authors conclude rightfully, that, there is a residual circulation through the minute vessels of the mesentery which cannot be wholly arrested by increase of intra enteric pressure

The Anatomy of the Ileocecal Sphincter and Valve

Textbooks of anatomy describe the ileocecal sphincter as a collection of circular and oblique muscle fibres surrounding the insertion of the two folds of mucous membrane of the terminal ileum into the colon These folds project into the lumen of the colon and are known as the upper and lower lips of the ileocecal valve Its innervation and function have been studied by Hinrichsen and Ivy (1931), who concluded that it exhibited properties of a physiologic sphincter, that its tone was maintained by sphincteric stimulation, and that the vagus *carried both motor and* inhibitory fibres to the sphincter

The manner of insertion of the terminal ileum into the colon permits the lips of mucous membrane supported by the smooth muscle beneath to act as a check valve, such that fluid and gas may be emptied into the colon from the ileum, but having entered, their regurgitation back into the small intestine is prevented by the closure of the folds of mucous membrane The lips of the ileocecal valve, *however, when incomplete*ly developed, would not exhibit this check valve action On studying autopsy specimens of ileocecal valves from man, Burge (1939) found that one valve, usually the inferior was deficient in an appreciable per cent of instances Sperling (1936) has studied the nature of the behavior of the ileocecal valve and sphincter in both man and dog in some detail

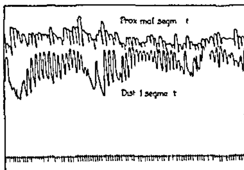


FIG 10—Activity of bowel proximal and distal to obstruction Copy of a kymographic tracing made in a dog with complete ileal obstruction of six days duration with a balloon in both the proximal and *distal loops The activity of both obstructed* and unobstructed bowel is great The unobstructed bowel is physiologically as well as anatomically normal Expulsion of gas and feces with an administered enema does not therefore militate against *the presence of obstruction* (Arch Int Med 46 669 1930)

Contractile Activity of Obstructed Bowel

Brandberg (1939) has given the matter of the motor activity of the obstructed bowel special consideration Employing an abdominal window, he observed first increased contractions, and with accretion of intestinal distension and impairment of the mesenteric circulation attending it decreased intestinal activity Carlson and Wangensteen (1930) noted good contractile activity of the bowel proximal and distal to the obstruction several days after the establishment of obstruction in dogs

The question of antiperistaltic activity in the obstructed bowel has not been settled wholly The recovery of lycopodium powder from the stomach after administration in an enema, Brandberg states is occasioned by action of the muscularis mucosae, which sets up a marginal current re

TABLE XII—EFFECT OF SUSTAINED INTRA ENTERIC PRESSURE UPON THE APPEARANCE PERMEABILITY, AND VIABILITY OF THE ILEUM

Dog	Pressure applied cm	Reoperated after hrs	Anatomy	Permeability	Viability
1	10 fluid	28	Petechial hemorrhage on anti mesenteric border	Negative	Viable
2	10 air	27	Petechial hemorrhage on anti mesenteric border, some bloody fluid in lumen of gut	Negative	Viable
3	20 fluid	10 22 28	Congested Congestion marked Hemorrhagic peritoneal fluid definite areas of necrosis on anti mesenteric border	Negative Negative Positive	Viable Impaired Non viable
4	20 air	22 32	Congested Dog dead necrotic areas	Negative Positive	Viable Non-viable
5	40 fluid	2	Negative	Negative	Viable
6	40 air	4	Hemorrhages on anti mesenteric border	Negative	Viable
7	40 fluid	11 17	Congested bloody fluid in peritoneal cavity Dog dead areas of necrosis	Negative Positive	Viable Non viable
8	40 fluid	28	Areas of necrosis on anti mesenteric border	Positive	Non viable
9	40 air	20	Split serosa gangrenous patch on anti mesenteric border	Positive	Non viable
10	40 air	20	Two areas of necrosis on anti mesenteric border	Positive	Non viable
11	40 fluid	20 24 30	Hemorrhagic areas and beginning areas of necrosis Necrosis spreading Two small distension ulcers on mucosal surface	Negative Negative Positive	Viable Non viable Non viable

for evidences of abnormal permeability in the wall of the distended bowel At intervals the abdomen of the dog was reopened and the surfaces of the distended loop were sponged with a 1 per cent solution of ferric chloride Penetration of the potassium ferrocyanide through the gut wall was heralded by the appearance of a definite Prussian blue color At the time of the reopening of the abdomen, the viability of the distended loops was tested by faradic stimulation Failure of the bowel wall to contract when stimulated with two dry cells, with the coils 8 centimeters apart, was

Effect of Constantly Sustained Pressure

In order to better evaluate the significance of the increased pressures which have been noted to exist in experimental as well as clinical obstructions, the intestine was subjected to sustained pressures of the grades observed and the bowel wall was carefully studied to note the effects of distension

Sperling and Wangensteen (1935) subjected closed ileal loops in the

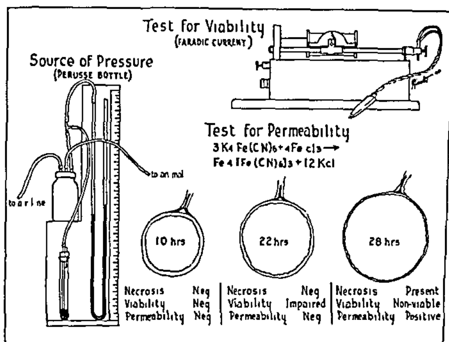


FIG 11—Schematic summary of effects of sustained intraluminal pressure in closed loops (See Table 12) Necrosis indicates histologic evidence of tissue injury response to the faradic current was used to indicate whether the bowel was viable (see text) The appearance of a Prussian blue color after daubing Ferric chloride on the exterior of the bowel indicated that the potassium ferro-cyanide had come through and that the bowel had become abnormally permeable At the left is shown the Peru se pressure bottle

dog to sustained increases of intraluminal pressure, maintained for hours at a predetermined level This objective was accomplished by employing the Perusse pressure bottle (Fig 11) The levels of pressure maintained were 10, 20 and 40 centimeters of water—pressures within the range of those observed clinically and following experimental obstruction in the dog The dogs, in these closed loop experiments, were maintained quiet under pentobarbital sodium (nembutal) anesthesia, reinforced with morphine for the duration of the experiment The anatomic effects of such distension are indicated in Table 12 Placement of 30 cubic centimeters of a 5 per cent solution of potassium ferrocyanide into the lumen of the closed loop prior to distending it, afforded at the same time, opportunity to test

TABLE XII —EFFECT OF [illegible] [illegible]ENTERIC PRESSURE UPON THE APPEARANCE [illegible] VIABILITY OF THE ILEUM

Dog	Pressure applied cm	Reoperated after hrs	[illegible]	Permeability	Viability
1	10 fluid	28	[illegible] [illegible]age on anti [illegible]	Negative	Viable
2	10 air	27	[illegible] [illegible]rrhage on anti [illegible] border some [illegible] lumen of gut	Negative	Viable
3	20 fluid	10 22 28	[illegible] marked [illegible] peritoneal fluid [illegible] areas of necrosis on [illegible]enteric border	Negative Negative Positive	Viable Impaired Non viable
4	20 air	[illegible] 3[illegible]	[illegible] [illegible] necrotic areas	Negative Positive	Viable Non viable
5	40 fluid		[illegible]gative	Negative	Viable
6	40 air	[illegible]	[illegible] [illegible]morrhages on anti mesenteric border	Negative	Viable
7	40 fluid	[illegible] [illegible]	Congested bloody fluid in peritoneal cavity Dog dead areas of necrosis	Negative Positive	Viable Non viable
8	40 fluid	28	Areas of necrosis on antimesenteric border	Positive	Non viable
9	40 air	20	Split serosa gangrenous patch on anti mesenteric border	Positive	Non viable
10	40 air	20	Two areas of necrosis on anti mesenteric border	Positive	Non viable
11	40 fluid	20 24 30	Hemorrhagic areas and beginning areas of necrosis Necrosis spreading Two small distension ulcers on mucosal surface	Negative Negative Positive	Viable Non viable Non viable

for evidences of abnormal permeability in the wall of the distended bowel At intervals, the abdomen of the dog was reopened and the surfaces of the distended loop were sponged with a 1 per cent solution of ferric chloride Penetration of the potassium ferrocyanide through the gut wall was heralded by the appearance of a definite Prussian blue color At the time of the reopening of the abdomen, the viability of the distended loops was tested by faradic stimulation Failure of the bowel wall to contract, when stimulated with two dry cells, with the coils 8 centimeters apart, was

Effect of Constantly Sustained Pressure

In order to better evaluate the significance of the increased pressures which have been noted to exist in experimental as well as clinical obstructions, the intestine was subjected to sustained pressures of the grades observed and the bowel wall was carefully studied to note the effects of distension

Sperling and Wangensteen (1935) subjected closed ileal loops in the

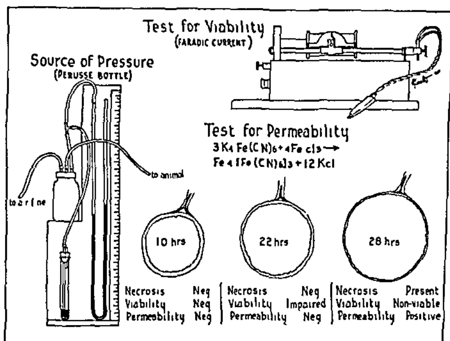


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obstructions He found that the rubor of the bowel was explained by the dilated vessels in its wall The vessels themselves were intact

The only significant changes present in this study were observed in the mucosa Swelling of the villi as well as shortening and clubbing described above in the artificially distended segments were constant findings Loss of the epithelial tips of the villi in specimens both from above and below the site of obstruction were occasionally noted Areas of leucocytic invasion or evidence of necrosis of the bowel wall were absent uniformly

Comment—It is to be observed that whereas sustained intra enteric pressures of the grades demonstrated to exist in at least some cases of bowel obstruction caused anatomical changes in the bowel wall (Table XII, pressures of 20 and 40 centimeters) these were not observed in any of the thirty five cases in which experimental simple obstructions were established This occurrence bespeaks the importance of the great ability which all hollow muscular viscera such as the bladder, stomach, and intestine exhibit to accommodate themselves to altered capacities without significant changes in tension Whereas sustained pressures in clinical cases of small bowel obstruction were observed to vary between 4 and 14 centimeters of water and in experimental obstruction of the small bowel of the dog between 4 and 19 centimeters, these were after all in each instance single observations made over a period of some few minutes The artificially produced increases of intra enteric pressure were maintained over hours Undoubtedly the bowel wall, within certain limits, is able to maintain an adequate blood supply through the process of stretching of its circular muscle The dilatation of the small bowel observed experimentally as well as clinically occurs so gradually that considerable distension may be present without marked increase in tension Yet, it is to be admitted freely, that the lower segments of a long stretch of obstructed bowel, in which the effects of long continued increases of sustained intraluminal pressure become most manifest are exposed to the same hazards that befall closed segments submitted to a constantly maintained intraluminal pressure

Influence of Length of the Segment

The length of the segment concerned is obviously of great importance The small bowel of the dog is considerably shorter than that of man and in consequence its lower reaches when obstructed may be evacuated with greater ease by retrograde peristalsis and vomiting than the lower ileum of the obstructed human gut Nevertheless, this feature of regurgitation into more proximal segments is undoubtedly the factor which is of paramount importance in preserving an adequate blood supply to the obstructed small intestine Its significance for the nutrition of the bowel wall may be appreciated better by referring to the absence of this occurrence in clinical cases of acute obstruction of the colon It should be stated here that though the ileocecal sphincter of the dog resists distension as has been related previously when dogs survive colonic obstruction for some time the terminal small intestine is found dilated usually On the contrary in acute mechanical obstruction of the colon in man, the

taken as evidence of impaired viability

A summary of the anatomic findings, together with the status relating to permeability and viability is to be found in the accompanying table (Table 12) It is to be observed that the time over which the pressure acts though not of the same significance for the bowel as the degree of pressure acting, is, nevertheless, very important It is to be noted that the continuous application of 10 centimeters sustained intra enteric pres sure for 27 or 28 hours (dogs 1 and 2) caused petechial hemorrhages in the gut, even though the bowel was viable and no abnormal permeability for potassium ferrocyanide was demonstrated The employment of 20 centimeters water pressure for 28 or 32 hours (dogs 3 and 4) caused areas of necrosis and the bowel was no longer viable as tested by response to faradic stimulation, it was also abnormally permeable When pressures of 40 centimeters were employed, the bowel exhibited invariably necrotic areas after 17 to 20 hours and was abnormally permeable and non viable Sperling (1938) has elaborated upon these observations

Histology of the Bowel Wall

Histologic studies made upon the bowel wall, in the viable segments, showed thinning of the wall and prominent blood vessels exhibiting collections of red cells There was no interstitial hemorrhage Edema, shortening and clubbing of the villi were fairly constant findings In the nonviable segments interstitial hemorrhage and erosion of the mucosa were invari able findings

Histologic studies were made also upon the bowel in a number of instances of experimental simple intestinal obstruction One or two speci mens were taken from the bowel distal to the obstruction and one to four specimens were removed from the obstructed proximal gut at various levels between the pylorus and the point of obstruction The entire proximal bowel was opened up and specimens were selected from areas that appeared to deviate from the normal in gross appearance These tissues as well as pieces selected for histologic study of the segments which had been subjected to sustained increased pressure listed above, were fixed in formalin or Zenker's solution, imbedded in paraffin, and microscopic slides were prepared employing the hematoxylin and eosin stain

Tissues from nine dogs with duodenal obstruction varying in duration from three to six days were available for study, seventeen ileal obstructions of two to fourteen days' duration, and nine colonic obstructions of two to nineteen days' standing

Grossly all the distended obstructed segments exhibited redness of the bowel wall No areas of necrosis of the wall or mucosal ulceration were seen in any of these thirty five obstructions No evidence of interstitial hemorrhage was observed in any of the sections studied microscopically The rubor of the bowel wall was adequately accounted for in the constant finding of collections of red cells in dilated blood vessels These observa tions are in accord with the conclusions of Morton (1929), who injected the blood vessels to the bowel wall with India ink after experimental

however support the opinion expressed by Burget and his associates that a low level of blood chloride does not accompany devitalization of the bowel wall *per se*

It has been pointed out already that the greatest stress is borne by that portion of the dilated gut which has the largest diameter With a knowledge of the sustained intra enteric pressure and the measurement of the diameter of the distended segment, the tension is calculated readily The tension T, on every centimeter of surface of the segment will be equal

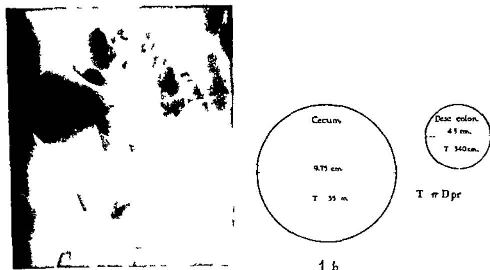


Fig 12—The role of the ileocecal valve and sphincter in acute obstruction of the colon (a) The distension of the colon in a patient with an obstructing annular carcinoma in the pelvic colon The ileocecal sphincter precludes regurgitation into the ileum and creates a closed loop obstruction (b) The tension on the walls of the obstructed bowel in the cecum and descending colon is indicated in the accompanying sketches

to the diameter, D in centimeters multiplied by pi π, times the intra enteric pressure, P, in centimeters of water How the diameter affects the tension may be shown readily by the following A patient with an acute obstruction of the pelvic colon presented himself with the distension shown in Figure 12 The greatest diameter of the distended bowel was 13 centimeters in the cecum, the diameter of the descending colon was 6 centimeters At operation a carcinoma was found in the pelvic colon The entire anterior wall of the cecum was gangrenous from which complication the patient died despite successful decompression Unfortunately the intra enteric pressure was not measured, but it has been determined in similar cases which will be referred to in a subsequent section of this paper Let us assume that the intra enteric pressure was 24 centimeters, which is well within the limits of pressures actually measured in similar cases The difference in stress borne by the cecum and descending colon is indicated in the accompanying calculation Inasmuch, however, as the film is made with the patient lying supine, the intestinal coils are a

distension is limited usually almost *invariably to the colon itself* The ileocecal valve and sphincter in man behave like a check-valve and preclude frequently the regurgitation of colonic contents back into the ileum The capacity for dilatation is possessed by the colon in the same degree as the small intestine, but there being no participation in the distension by the small intestine, such an obstruction becomes virtually a short, closed loop obstruction Whereas experimentally produced closed loops of the colon (both ends closed) may be well tolerated, when the contents of the ileum are poured into the obstructed colon and no avenue is present for *their escape, the occurrence of anatomical changes in the bowel wall* and perforation may be understood readily Whereas several instances of perforation of the obstructed colon have come under the observation of the writer, no instance of perforation of the small intestine among a much larger number of clinical cases of simple obstruction has been seen However, as explained above, the lower reaches of a long stretch of distended bowel are subjected to the same hazard, as attends closed loops Lufkin (1938) has observed actual perforation in simple obstruction of the small bowel in man The end effects of distension upon segments of bowel, subjected to an unrelenting stretch, are undoubtedly similar to primary strangulations in which the blood flow is compromised The shock like effects of terminal simple obstruction, described by Moon and Morgan (1936), are understandable in the light of the demonstrated increased permeability of distended intestinal loops

The verity of these observations concerning the distension factor is further borne out by a large number of investigators who have worked with closed intestinal loops This significant method of studying the effects of bowel obstruction was introduced by Stone, Bernheim and Whipple in *1913*

The Hydraulic Stress Factor

The significance of the hydraulic factor in determining the course of events in animals having closed loops was pointed out by Sweet and associates (1916) who said, "It is only because of such distension and consequent rupture that our animals with closed loops die" The greater danger inherent in the upper intestinal loop has been noted by a number of investigators, as has also that, longer loops are better tolerated by the animals than the short ones Burget and his associates (1930) were able to have some dogs survive short closed jejunal loops for months by periodically aspirating their content When the closed loop was not aspirated, the dog manifested obvious signs of illness and would not eat these symptoms were relieved uniformly by aspiration Histological studies of aspirated loops showed no alteration, whereas *necrosis and perforation occurred in* those not aspirated Herrin and Meek (1933) have produced similar symptoms in dogs by artificially distending intestinal loops Unlike the findings of Burget and his associates, however, Herrin and Meek believed that significant losses of chloride were produced by distension which gave rise to the typical blood chemical alterations attending obstruction of the upper reaches of the intestine The findings of a number of investigators

nervation of the loop was carried out, survived establishment of such closed intestinal loops for 3 weeks to 4 months

The experiments suggest a definite role of the nervous factor in the production of the symptoms and effects of a closed loop Yet, it is essential to know what the effect of denervation, accomplished in this manner, is on the secretion of the loop It is significant that Fine and his associates (1939) were unable to detect any difference, in behavior, of denervated closed loops over controls, when denervation was carried out by removal of the celiac ganglia

C THE SYSTEMIC EFFECTS OF INTESTINAL DISTENSION

Intestinal distension, inadequate in degree to embarrass respiration, may, nevertheless exercise a measurable objective effect upon the circulation In patients with obstruction of the small intestine or the colon exhibiting intraluminal pressures (determined at operation) from 14 to 20 cms of water pressure Bellis and the writer (1939) observed definite elevation of the venous pressure in the ankle veins of the lower extremity

TABLE XIII —VENOUS PRESSURE (ANKLE VEIN) AND CIRCULATION TIME (ANKLE VEIN TO CAROTID SINUS BY SODIUM CYANID METHOD) IN PATIENTS WITH CLINICAL INTESTINAL DISTENSION

Case	Venous pressure ankle (cm water)	Circulation time (seconds)	
		Cubital to carotid	Ankle vein to carotid
1 Carcinoma of pelvic colon with acute obstruction pressure at operation 20 cm water 1800 cc gas aspirated	12	20	52
2 Carcinoma of pelvic colon pressure at operation 15 cm water 1500 cc gas aspirated	15.5	19	No response in horizontal 22 in 30 Trendelenburg
3 Carcinoma of stomach with distension owing to metastases	17.5	18	No response in horizontal 15 in 30 Trendelenburg
4 Mass in terminal ileum treated conservatively by suction 5 days later ileostomy intraluminal pressure 14 cm water 600 cc gas and fluid aspirated at operation	3	22	35
5 Abdominal injury with marked intestinal distention treated conservatively by suction applied to indwelling duodenal tube	29	12	49

Downward inclination

(12 to 29 cms of saline pressure) before surgical relief of the distension was undertaken There was observed also a consistent definite prolongation of the circulation time in the lower extremity (35 to 52 seconds, as

considerable distance from the film and appear in consequence much larger than they actually are The degree of enlargement of intestinal diameter as determined by a comparison of the measurements made upon the obstructed bowel at operation and that observed on the roentgen film is in the neighborhood of 25 per cent, because of the divergence of the x-rays Allowing for this error, the stress T upon the walls of the two segments will be as follows

For the cecum

$T = 3.14 \times 13 \times 24 \times 0.75,$

$T = 735$ centimeters of water pressure per centimeter of surface

For the descending colon

$T = 3.14 \times 6 \times 24 \times 0.75,$

$T = 340$ centimeters

The frequency with which perforation is observed in the cecum in late or neglected cases of obstruction of the pelvic colon is apparent immediately in the difference of stress or tension exerted on the walls in segments of varying diameter as indicated by this calculation

Neurogenic Factor in Closed Loops

Lawson and Chumley (1940) have studied recently the blood flow to distended intestinal segments in the dog Employing a closed intestinal loop, and pressures not less than 30 millimeters of mercury nor more than 60, in acute experiments of short duration (not more than five minutes), they failed to observe any evidence of significant differences of blood flow, during the period of distension Lawson and Chumley believe that stretching of the bowel wall, incident to distension, either reduces the resistance to the flow of blood, or, sets in operation a peripheral nervous mechanism which lowers resistance to blood flow, by compensating for the rise in extravascular (intra enteric) pressure The ultimate compensating mechanism, they believe, is, probably, dilatation of the intestinal arterioles When Lawson and Chumley prevented enlargement of the intestinal loop by encasing it in plaster of Paris, prior to distending it, or, when the loop was treated with cocaine or procaine, rises in intra enteric pressure were followed consistently by reduction in blood flow, which persisted throughout the period of distension

A number of investigators, Burget and his associates (1930), Herrin and Meek (1933), Taylor and his associates (1933), Antoncic and Lawson (1941) amongst others have observed lesser symptoms and longer survivals in dogs with closed intestinal loops, attending denervation of the loops Antoncic and Lawson, who studied this nervous factor most recently, cut the periarterial tissue about the blood vessels in the loop concerned, and then painted the denuded area over the vessels with a 20 per cent solution of phenol In other experiments, they infiltrated the mesenteric pedicle of the closed loop with 95 per cent alcohol Whereas, the control dogs died in 36 hours to 7 days, 11 of 23 dogs in which de-

about in that the blood has yet to flow through the liver capillaries (Table XIV)

It is clear, therefore, that distension causes stasis of blood in the lower extremities, and in the gut itself Aird (1937) and Gendel and Fine (1939) have described reduction in plasma volume in ileal obstruction in dogs Both groups of writers felt that the loss in plasma volume was inadequate in amount to cause death When, however, Gendel and Fine subjected the obstructed loops of intestine to sustained intraluminal pressures of 20 to 40 cms of water sufficient losses of plasma to cause death were the rule In a recent communication (1940) Fine and Gendel state that while the loss of plasma is not the only significant phenomenon in the lethal

TABLE XIV—RELATION OF INTRALUMINAL PRESSURE IN BOWEL OF DOGS TO MESENTERIC VENOUS PRESSURE ATTENDING INFLATION OF GUT WITH AIR

Intraluminal pressure (cm water)	Mesenteric venous pressure (cm water)
0	13
10	12
20	12
30	12
40	10
50	6
60	5 5
70	5
80	5
90	6
100	6

process of intestinal obstruction they feel it is the only one brought forward thus far which may be regarded as basic in importance"

This writer feels, on the contrary, that significant plasma losses in bowel obstruction apart from the segregation of blood in the lower extremities occasioned by intestinal distension is a measure of impaired viability of the bowel wall Since the observations of Bayliss and Starling (1894) it is known that the capillaries of the intestinal mucosa and the liver *are more permeable to protein than are other* capillary blood vessels Yet as Landis (1934) has indicated capillaries unless injured retain 95 per cent of the plasma protein Whereas peritoneal fluid can be collected regularly containing protein in abnormal amounts (3 to 6 per cent) after long intestinal loops have been subjected to sustained increases of intraluminal pressure of 10 to 20 cms of water pressure for some time, it is often difficult to collect fluid from the peritoneal cavity of the dog with ileal obstruction until *shortly before death Fluid is no doubt,* filtered through the capillaries into the peritoneal cavity, but only when the intestinal capillaries become injured through prolonged distension and anoxia with consequent abnormal leakage of protein through the capillaries does the circulatory mechanism break down, paralleling the situation observed in peritonitis

well as occasional absence of response—ankle vein to carotid sinus by the sodium cyanid method) over the circulation time in the upper extremity (12 to 22 seconds) Employment of the steep Trendelenburg posture (downward inclination of head and entire body at 30 degree angle) resulted in considerable acceleration of the circulation time in these same patients exhibiting intestinal distension (Table XIII)

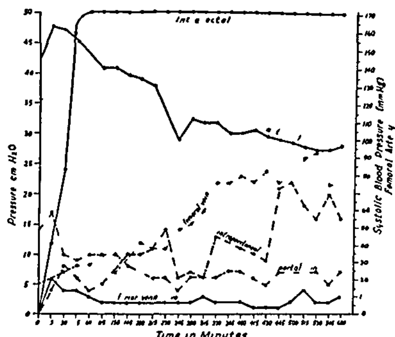


FIG 13—Intraintestinal air insufflation and its effects on venous pressure Relation between arterial blood pressure femoral venous pressure inferior vena cava pressure intraperitoneal pressure and portal venous pressure Intrajejunal pressure 50 cm water (Bellis and Wangensteen Proc Soc Exp Biol & Med 41 490 1939)

Attending maintenance of an intraluminal pressure in the bowel of 50 cm of water pressure, by the intrarectal insufflation of air, a gradual reduction of the arterial pressure occurs (Fig 13) The femoral vein pressure rises, the vena cava pressure remains largely uninfluenced, due probably to the protection which its strong fascial sheaths afford, the portal vein pressure falls slightly and the intraperitoneal pressure interestingly enough does not reflect directly the intra enteric pressure—the intraperitoneal pressure lagging definitely behind the intra enteric pressure

In dogs, it was observed that inflation of the bowel, to the extent that considerable intestinal distension resulted, reduced the venous pressure in the mesenteric veins That is, the rate of outflow of blood from the gut was reduced The initial mesenteric venous pressure was reduced from 12 cms of saline solution to 6 and 5 cms It is to be remembered that this relatively high normal venous pressure in the portal tributaries comes

that such may occur And justifiably so, for does not the intact intestinal cylinder afford the organism adequate protection daily against fatal infection and other potential serious menaces which constantly threaten? The most important element in the bowel wall responsible for providing this protection is undoubtedly the mucosa There is little wonder that no one can put aside wholly the thought that abnormal absorption may occur, particularly when changes, even though slight, such as edema or clubbing of the villi may be seen in histologic sections of the obstructed bowel whose wall is otherwise histologically normal

The Avenues of Absorption

The normal mode of absorption from the bowel is through its mesentery and may occur by the lymphatics or through the mesenteric radicles of the portal vein In addition it is believed that under conditions of obstruction, transperitoneal absorption through the bowel wall itself may obtain also It is therefore of the utmost significance to determine how obstruction and increased intra intestinal pressure influence absorption from the bowel

Absorption of Substances to which the Normal Bowel Is Permeable

It has been demonstrated adequately that the obstructed bowel permits the absorption of substances from its lumen to which the normal bowel wall is permeable Braun and Borrutau (1908) found that strychnine is absorbed from the obstructed intestine of the dog but at a slower rate than from the normal intestine Clairmont and Ranzi (1904) found in the first ten hours following the establishment of obstruction in the dog that absorption of calcium iodide was increased after ten hours its absorption was reduced in amount and after fifteen hours absorption sank quickly to a low level Enderlen and Hotz (1911) observed that the absorption of various concentrations of saline solution and dextrose was reduced from the intestine of obstructed dogs from the start

Absorption of Water from the Normal and Obstructed Bowel

Sperling (1938) studied the absorption of water from normal and obstructed bowel in dogs In four normal dogs, eighteen inches of the lower ileum was isolated by stripping this length of its content by a "milking" process A rubber covered clamp was applied at each end Tap water the temperature of which was 40° centigrade, was then injected into the lumen of this isolated loop to completely fill the loop without stretching the bowel A similar procedure was done in two dogs in which ileal obstruction had been established four days previously The eighteen inches of ileum to be selected in the obstructed dogs was demarcated at the time of obstruction to eliminate error due to alteration of the bowel length (shortening) which occurs with obstruction

The obstructed bowel Sperling observed absorbed only 8 to 10 per cent of the amount of water introduced, whereas in the normal 82 5 to 94 per cent was absorbed It would appear therefore, that water absorption is considerably retarded from an obstructed bowel

Neither is it likely that this phenomenon of plasma loss is peculiar to the small intestine as Fine and his associates have suggested Bellis and the writer (1939) observed increases in venous pressure in the lower extremities and delay in circulation time in colonic as well as small bowel obstructions The total length of the colon, it is to be borne in mind con stitutes only *about 20 per cent of the entire length of the bowel And the* frequent limitation of distension to the colon by the lips and sphincter of the ileocecal valve in colonic obstructions has been described above Un *doubtedly, therefore, the* greater surface area involved in obstructions of the small intestine suggests that this phenomenon may be observed more *often in small bowel obstructions*

The abnormal leakage of plasma protein through the intestinal capil laries accompanying the distension of obstruction indicates, as does trans-peritoneal migration of colloidal dyes, bacteria and other noxious agents such as strychnine and botulinum toxin placed in the lumen of the gut that the viability of the intestinal wall has become impaired by venous stasis and anoxia

D ABSORPTION IN OBSTRUCTION

The toxin absorption idea has held sway for a long time as *the* impor-tant factor in the lethal issue of bowel obstruction It is probably the oldest of all the theories seeking to explain the cause of death in intestinal obstruction More than a century ago, Amussat (1839) gave renewed em phasis to its importance Up until recently it has continued to lead the *field, amongst plausible causes, as the most significant lethal factor in* intestinal obstruction From filtrates of the intestinal content obtained from obstructed animals toxins have been isolated heteroproteose (Whip ple and associates), histamine (Gerard), nucleoprotein (Ingvaldsen and associates) and choline and neurine (Nesbitt) A number of observers *noted that normal intestinal content is equally as toxic as that from ob* structed intestinal segments (Roger and Garnier (1905), Wangensteen and Chunn (1928), Gatch Trusler and Lyons (1934) and Van Beuren (1935)

That bacteria multiply in obstructed intestinal loops has been demon strated adequately (MacNeal and Chase 1913 Gorke 1922 and Meleney Jobling and Berg 1927) The Dragstedts (1922) observed that preliminary washing and chemical sterilization, in so far as is practical eliminated largely the hazard of closed intestinal loops Davis and Stone (1913) found that mucosal preparations from obstructed intestine lost their toxicity after elimination of the bacteria from the filtrate Scott (1938) observed that, following autoclaving, excised intestinal loops could be implanted into the peritoneal cavities of other dogs, with impunity

In addition to consideration of the presence of an abnormal toxin in intestinal obstruction, foreign to the unobstructed bowel the item of ab sorption of substances, normally present within the lumen of the bowel, but to which the normal bowel wall is impermeable, is given wide credence as an item of great importance, in bringing about the lethal issue in in testinal obstruction Even in the minds of those who have tried and failed to demonstrate proof of abnormal absorption, there still lurks the fear

that such may occur And justifiably so, for does not the intact intestinal cylinder afford the organism adequate protection daily against fatal infection and other potential serious menaces which constantly threaten? The most important element in the bowel wall responsible for providing this protection is undoubtedly the mucosa There is little wonder that no one can put aside wholly the thought that abnormal absorption may occur, particularly when changes, even though slight, such as edema or clubbing of the villi, may be seen in histologic sections of the obstructed bowel whose wall is otherwise histologically normal

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Absorption of Histamine from the Obstructed Bowel

Mucosal extracts of dogs ill of obstruction, when injected intravenously into normal dogs, cause them to be profoundly ill accompanied by considerable depression of the arterial blood pressure Though a number of investigations show that no toxin is present in the obstructed bowel, foreign to the normal, it is commonly stated on the evidence just related that a histamine like substance is present in the obstructed bowel, the absorption of which gives rise to toxic symptoms

In order to appraise the significance of the possible presence of histamine in the obstructed gut, Wangensteen and Loucks (1928) injected 50 to 100 milligrams of histamine dichloride into the lumen of isolated segments in the duodenum as well as ileum of dogs with obstruction of forty eight hours duration Blood pressure tracings were made to test for the absorption of histamine No fall in blood pressure attended the injection of these doses of histamine into the bowel of one normal and seven obstructed dogs The employment of varying grades of increased intra enteric pressure failed to elicit the physiologic response of histamine absorption as reflected in the blood pressure When, however, a few cubic centimeters of the loop content were injected into a mesenteric or systemic vein, an immediate fall in blood pressure occurred In three additional dogs histamine was injected slowly by the drip method into a mesenteric vein, 0 83 milligrams being injected per minute There was an immediate and profound fall of blood pressure which continued as long as the histamine was given, and from the effects of which one of the animals failed to recover

These slow injections indicate that the liver does not detoxify any considerable amount of histamine The absence of blood pressure drops attending the placement of histamine in an obstructed loop indicates that if histamine is absorbed it is detoxified in going through the bowel wall

Venous Absorption from the Obstructed Bowel

Sugito (1924) and Scholefield (1927) showed to their own satisfaction that portal blood obtained from dogs in the agonal stages of bowel obstruction was toxic on intraperitoneal injection into mice, whereas normal portal or systemic blood was non toxic Inasmuch, however, as blood equal in amount to 10 per cent of the body weight of the mice was necessary to obtain positive results it is apparent that the source for error in the method is great Knight and Slome (1936) report recovery of a toxic substance from the superior mesenteric vein, when the entire gut of a cat was strangulated McLean and Andries (1912) and Werelius (1922) failed to elicit toxic effects in transfusing normal dogs with systemic blood from dogs with intestinal obstruction Whipple and his associates (1913) injected intravenously into a normal dog a large dose of toxic material prepared from the mucosa of obstructed animals Two hours later the whole blood volume of this ill dog was injected into another without making the recipient ill

Experiments—Carlson, Lynch and Wangensteen (1930) investigated

the potential toxic effect of portal venous blood of dogs dying of intestinal obstruction in the following manner Six dogs were obstructed by severing and inverting the ends of the lower ileum under aseptic conditions When it was apparent that the obstructed animal was failing rapidly, the abdomen was opened under ether anaesthesia and a large mesenteric vein was divided and the portal blood collected into a 3 per cent solution of sodium citrate 10 cubic centimeters of this solution being employed for every 100 cubic centimeters of blood The blood thus obtained was injected into the external jugular vein of a normal anesthetized dog under aseptic conditions and the blood pressure of the recipient was registered by means of a cannula introduced into one of the carotid arteries

Two other experiments were employed as controls In one of these 220 cubic centimeters of blood was obtained from the carotid artery of a normal dog and collected in citrate solution To this citrated blood, 10 milligrams of histamine dichloride was added In the other control 100 cubic centimeters of a 1 per cent sodium citrate solution was administered intravenously without the addition of blood

Results—Transfusion of blood from the normal donor, to which histamine was added resulted in an immediate and protracted drop of blood pressure to about one half of the original reading despite the increase in blood volume, seventeen minutes later, the blood pressure had regained practically its initial normal level The injection of the citrate solution without the addition of blood resulted in slight elevation of the blood pressure of the recipient

In all of the six animals transfused with the portal blood of six other dogs dying of simple obstruction, a definite increase of blood pressure was obtained soon after the transfusion was begun This elevation of pressure was sustained for several minutes and then there followed a gradual decline to the original level In no instance was there a decrease in pressure following the transfusion of blood The rise in blood pressure obtained in these experiments is undoubtedly a plethora effect It is significant that portal blood of dogs dying of intestinal obstruction failed to exhibit the physiologic test for histamine the addition of 10 milligrams of histamine dichloride to systemic blood from a normal dog when injected caused immediate profound and protracted depression of arterial pressure in the recipient

The Manner and Degree of Absorption in Obstruction

Though the avenues by which absorption may occur in bowel obstruction are well known it is extremely difficult to ascertain exactly in what manner and to what degree absorption may occur by way of any of these routes It is possible, however, by the employment of poisons (such as strychnine) and dyes with the aid of processes excluding certain avenues of absorption to gain some information upon this important matter

Experiments—Sperling and Wangensteen (1935) studied mesenteric venous absorption in the following manner For the determination of degree and rapidity of venous and transperitoneal absorption, 50 milligrams of strychnine sulphate were injected into the lower ileum of two normal

dogs anesthetized with ether Convulsions developed in 2 to 3 minutes In two other dogs in which sodium pentobarbital (nembutal) was employed for narcosis, convulsions were delayed to five and eight minutes (It has recently been shown that barbital derivatives retard strychnine convulsions) In four dogs in which simple ileal obstruction had been established from 24 to 96 hours previously, convulsions occurred 6 to 13 minutes after the injection of strychnine into the obstructed segment In two dogs, a loop of terminal ileum was completely devascularized by cutting the mesentery, 50 milligrams of strychnine sulphate were injected into each, convulsions were delayed for 8 and 15 hours In two other dogs, following the injection of strychnine into the terminal ileum with its blood supply intact, the loop was placed upon the abdominal wall, convulsions appeared after 8 to 15 minutes, corresponding roughly in time to that observed when the bowel had been obstructed for 24 to 96 hours

From these experiments it is apparent (1) that previous simple obstruction delays the absorption of strychnine slightly, (2) that placing the gut in an extraperitoneal position delays absorption slightly, (3) that cutting off mesenteric absorption by devascularization delays absorption considerably, absorption then occurring by the transperitoneal route when the bowel is no longer viable The experiments indicate that the mesenteric route (probably venous) is far more important for the absorption of strychnine than is the transperitoneal

The effect of increased intra enteric pressure upon the absorption of strychnine over these routes is apparent in the following With an intact mesentery convulsions are delayed but occur until an intra enteric pressure of 70 millimeters of mercury is exceeded following which no convulsions are observed for hours Whereas when loops were devascularized (as just mentioned above) no convulsions were observed in two dogs until after 8 and 15 hours respectively, when similar devascularized loops were distended under 100 millimeters of mercury pressure, convul ions were observed in 3 hours

How an antecedent obstruction affects transperitoneal absorption (permeability) is apparent in the following It has been related that when strychnine was injected into devascularized loops convulsions appeared in two dogs after 8 and 15 hours When two dogs were obstructed for 72 hours and the terminal obstructed segments were devascularized and injected with strychnine, convulsions appeared in 3 and 4 hours

Experiments similar in practically every particular to all these just related above were carried out on a larger number of cats (thirty eight) with almost identical results Strychnine sulphate was injected in 10 milli gram doses convulsions as a rule, appeared slightly earlier than in the dogs

In previous experiments relating to the absorption of potassium fer rocyanide from the gut under measured increased intra enteric pressure, it was shown that transperitoneal absorption is correlated fairly directly with loss of viability It is apparent therefore, that previously obstructed

gut following devascularization becomes non viable and abnormally permeable more readily, than does a bowel whose wall was normal up to the time that its blood supply was cut off

Lymphatic Absorption

The lymphatic absorption of dyes has been studied by a number of workers Stabins and Morton (1929) put colloidal silver into obstructed loops but could not demonstrate its presence in the vessels or walls of viable intestine The dye was found in the lymph stream only when the bowel was perforated Schempp (1928) and Kagan (1931) showed that vital dyes as trypan blue, were absorbed with greater facility from the obstructed bowel of the dog than from the normal

Experiments—Sperling and Wangensteen (1935) studied the lymphatic avenue of absorption in the following manner Controls—In a group of five normal cats an enteric injection of 20 cubic centimeters of 170 trypan blue was made under ether anesthesia At intervals of 2 5, 18, and 48 hours the abdomen of each cat was reopened There was no evidence of staining of the lymph nodes Recognizing that transport might have been so rapid that absorption could not occur a chemical peritonitis was induced by irritating the visceral and parietal peritonea with tincture of iodine (5 cubic centimeters) in six cats A lethal issue occurred in all between 24 and 72 hours In only one cat were the mesenteric nodes stained

Simple obstruction—Simple ileal obstruction was established in four cats and 20 cubic centimenters of 1 per cent trypan blue was injected into the bowel above the site of obstruction with a fine needle These cats died in 24 72 72 and 120 hours respectively The results were negative with the exception of the 120 hour survival, in which cat a few of the mesenteric lymph nodes exhibited blue spots

A similar obstruction was established in ten other cats and 20 cubic centimeters of a 1 per cent solution of gentian violet was injected, four cats were sacrificed at 48, 72 96, and 144 hours no coloration of the lymph nodes was apparent The remaining six cats were allowed to die of their obstruction death occurring on the average 68 hours later, varying between 24 and 144 hours In two of these, the mesenteric lymph nodes were purple

Closed loop obstructions—In nine cats closed loop obstructions were made in the terminal ileum and 20 cubic centimeters of 1 per cent gentian violet was injected into the loop Four animals were sacrificed at 24 24, 72 and 72 hours respectively The mesenteric lymph nodes were purple in all instances Five cats were allowed to die of their obstructions death occurring between 24 and 96 hours The mesenteric nodes were purple in three but were not stained in two

Trypan blue was injected into closed loops of three cats The periods of survival in each case were respectively 24 72, and 72 hours The mesenteric nodes were blue in each instance

Comparison of Lymphatic Absorption from Simple and Closed Loops and the Significance of Increased Intra enteric Pressure

In three of fourteen cats with simple obstruction, the lymph nodes were colored after intra enteric injection of gentian violet or trypan blue In twelve cats, ten showed coloration of the mesenteric lymph nodes following the establishment of closed loop obstructions

These results indicate the greater likelihood of lymphatic absorption under the influence of increased intra enteric pressure as exists in closed ileal loops These findings were corroborated by employing increased intraluminal pressures In two cats with closed loops first established, the employment of 100 millimeters of mercury pressure following the injection of gentian violet into the loop caused the appearance of the dye in the regional lymphatic vessels of each cat in ten minutes, 50 millimeters of mercury pressure was employed in another cat, and the dye appeared in the neighboring lymph vessels in an hour In another cat in which a simple obstruction of the terminal ileum had been established 48 hours before, the employment of 40 millimeters of mercury pressure forced the dye to appear in the lymph vessels in 30 minutes

These observations are in accord with the well known physiological principle that increases of venous pressure enhance the rate of lymph flow The appearance of the dye in the lymph vessels of cats with simple obstruction that were allowed to die of their obstruction and failure of the mesenteric nodes to be stained in animals with simple obstruction that were sacrificed are readily understandable in that lymph flow continues after death (Drinker and Field (1933), Bainbridge (1906)

The Influence of Obstruction upon the Lymphatic Absorption of Bacteria

A number of investigations show that bacteria may be isolated occasionally from the mesenteric lymph nodes under presumably normal conditions Adami (1914) obtained positive cultures of intestinal bacteria from mesenteric lymph nodes of apparently healthy animals Shuger and Arnold (1931) recovered *Bacillus prodigiosus* organisms from mesenteric lymph nodes following their introduction into the rectum of animals, David and McGill observed that trauma or obstruction of the colon caused an increase in number of bacteria in the mesenteric lymph nodes

Experiments—A few mesenteric lymph nodes were excised for preliminary culture from several cats, all proved negative A heavy suspension of *Bacillus pyocyaneus* was then injected into the ileum of six of these same cats Cultures were then taken from these nodes one hour after the introduction of the pyocyaneus organisms, in two instances positive cultures were obtained, four were negative Two of these four latter animals however, yielded positive cultures when reoperated upon after 24 hours In two additional cats, previously obstructed, the intra enteric injection of *Bacillus pyocyaneus* under increased pressure resulted in finding the organisms in the mesenteric lymph nodes after one hour in both instances

Similar experiments were performed upon normal and obstructed dogs

Control cultures of lymph nodes made before operation on nine normals were negative for bacteria Following the introduction of *Bacillus pyocyaneus* into the ileum of nine normals, two gave positive cultures of the mesenteric lymph nodes In six dogs with low simple ileal obstruction varying in duration from 24 to 96 hours, all were positive on subsequent culture Cultures of the thoracic duct lymph in five normals and six obstructed dogs after intra enteric injection of *Bacillus pyocyaneus* were negative for the presence of the organisms Cultures of femoral and portal blood were also negative Williamson and Brown (1923) had previously found negative cultures in the thoracic duct lymph of normal dogs after the introduction of *Bacillus prodigiosus* into the intestine Murphy and Brooks (1915), however, found a toxic material present in the thoracic duct in obstructed cats

An attempt was made to evaluate the significance of the absorption by interruption of lymphatic absorption This was done by ligating or cutting the lymphatic pedicle in the mesentery Following execution of this procedure in several cats the survival period was not prolonged

E THE SIGNIFICANCE OF THE BLOOD LOSS FACTOR IN STRANGULATION OBSTRUCTIONS

In some experiments described above, it was found that no evidence of histamine absorption could be demonstrated following its intra enteric injection into dogs with obstruction of the duodenum or ileum Histamine was injected similarly into a loop of small bowel strangulated with a tape ligature tightly tied in two dogs When the ligature was loosened, there was an immediate and protracted fall of blood pressure, when the ligature was tightened, the pressure rose At first, this occurrence was construed to indicate that the injury of the bowel wall attending constriction of the gut and its mesentery allowed histamine to be absorbed by way of the mesenteric vessels when the ligature was loosened It was soon observed, however, that when the injection of histamine was omitted (in six other strangulations) loosening of the ligature brought about a similar fall in pressure which was gradually corrected by tightening the tape ligature These results then appeared to indicate the occurrence of a toxic effect from absorption of autolyzed intestinal mucosa especially inasmuch as preliminary meticulous washing out of the content of the strangulated loop in two dogs failed to prevent this drop in pressure attending release of the intestinal ligature (Wangensteen and Loucks 1928)

When primary resection was performed in a group of dogs, (Wangensteen and Houkom 1928), 4 to 6 hours after the establishment of strangulating obstruction, by the application of a loose ligature, recovery followed in the majority of instances In another group of dogs, similar strangulating obstructions were established After 4 to 6 hours, the tape was loosened and the bowel, appearing viable, was allowed to remain This procedure was followed by a considerably greater loss of animals than occurred in the group in which primary resection was done This occurrence suggested two likely explanations (1) that excision of the strangulated gut arrested hemorrhage or (2) that excision of the strangulated

gut precluded continued absorption from the damaged loop

This deduction was subjected to further experimental scrutiny by Scott and Wangensteen (1932) in the following manner Similar blood pressure tracings were made on a number of dogs after (1) ligature of the veins to a segment of the gut, (2) ligature of the arterial supply to a similar segment, (3) complete division of the mesentery of the gut cutting both arteries and veins, and (4) encirclement ligature of a segment of gut and its mesentery

Briefly stated, the results of these experiments indicated clearly that

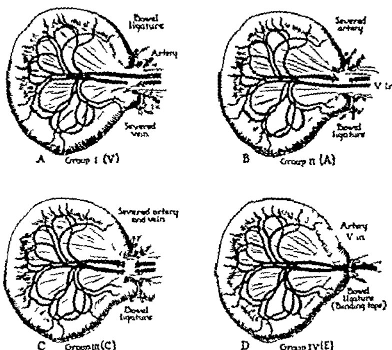


Fig 14 —Types of experimental strangulating obstruction A Encirclement ligature of bowel and vessel B Complete severance of mesentery with ligature of bowel C Arterial obstruction D Venous obstruction Beside the group number is listed the designation employed in Fig 15 to indicate the blood loss (Scott H G *Arch Surg* 36 816 1938)

there was a direct correlation between the manner of interference with the blood supply of the gut the arterial blood pressure, the length of the segment concerned (particularly in venous obstructions) and the survival time The ligation of veins (ten dogs) to a segment of small intestine varying in length from 2 to 5 feet caused severe falls in arterial blood pressure which resulted fatally in 2 to 4 hours In one dog in which the superior mesenteric vein was tied the arterial pressure which had been 140 millimeters of mercury initially, fell gradually and in an hour the dog was dead The longer the loop the more marked was the fall in pressure and the shorter the survival period

The results in group two (three dogs) in which the arteries were tied, and those of group three (three dogs) in which both arteries and veins were tied, were very much the same

Blood pressure tracings continued for 4 to 6 hours showed no significant alteration in pressure These animals survived for 16 to 20 hours In two animals, just before death, the arterial pressure was recorded again and found to be low The most variable results were obtained in group

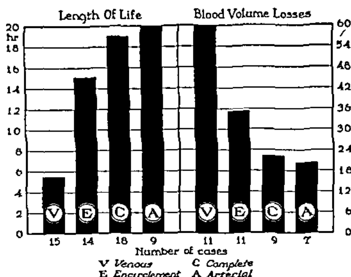


Fig 15—Blood volume losses and length of survival following various types of strangulating obstruction It is to be noted that the blood loss is greatest in the venous obstructions and the survival time is the shortest in this group In the arterial ligation group the blood volume loss (20%) represents undoubtedly plasma loss owing to increased capillary permeability (protein content of peritoneal fluid 6%) coincident to death of bowel Complete division of the vessels imitates the effects of arterial ligation closely Encirclement ligature (depending on how tightly the mesentery and bowel are tied) may partake of the features of venous or arterial ligation [Summary of data published by Scott and Wangensteen *Proc Soc Exp Biol & Med* 29 749 1932 and published in extended form by Scott *Arch Surg* 36 816 1938]

four (sixteen dogs) in which an encirclement ligature was placed about the bowel Blood pressure tracings were carried over an interval of 3 to 7 hours in each dog On the whole it may be said that no significant falls in pressure occurred In six dogs falls in arterial pressure of 30 to 40 millimeters of mercury occurred in this time interval In the larger number, however the readings were normal at the end of several hours In this group one variable in addition to the length of gut concerned was present that did not obtain in the others viz, the degree of tightness of the encirclement ligature

It was evident from these experiments that the blood loss factor was the significant item in determining whether an early severe fall in arterial blood pressure would occur Whether the arteries alone or the arteries

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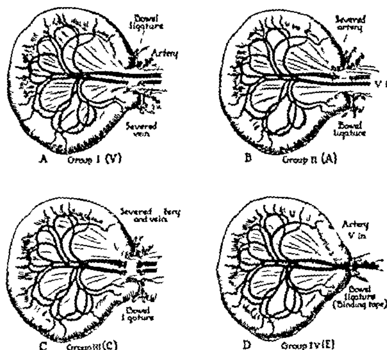


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The hemoglobin content of the blood tinged peritoneal cavity in these instances averaged a little less than 1 per cent Protein determinations made on the peritoneal fluid however, showed it to be not unlike blood plasma Calculated on this basis, despite the fact that the actual blood loss was not great in the instances in which the arteries were tied, it could still be contended that the blood volume loss was significant and averaged about 20 per cent Scott (1938) has elaborated upon these observations

Comment—These experiments indicate that the blood loss factor is significant in strangulating types of obstruction, particularly where the venous obstruction factor predominates Pure forms of arterial obstruction are to be seen clinically probably only in instances of arterial thrombosis or embolism Venous thrombosis of the mesenteric vessels, increased intraluminal pressure, in instances in which it becomes great enough to occlude the veins and the various types of torsion encirclement and invagination of the gut are essentially instances of venous obstructions of varying grade In all of this latter group, particularly where the segment concerned is long, the blood loss factor may produce actual surgical shock

It is also apparent that accompanying threatened or actual loss of viability of the gut, abnormal permeability and transperitoneal absorption may occur In the arterial obstruction group which survived for 16 to 20 hours this undoubtedly was the chief factor in the cause of death, the greater number of these segments deprived of arterial blood being found ruptured at necropsy

The recovery of a fluid with a 6 per cent protein content from the peritoneal cavities of dogs having arterial obstruction alone to a loop suggests that lack of oxygenation had impaired the viability of the bowel wall, permitting abnormal capillary filtration

The relationship of viability and permeability as related to increased intra enteric pressure has been discussed previously These latter experiments afforded an opportunity to determine in what manner interference with the arterial inflow or venous return of blood influences the factors of viability and permeability These observations (Scott and Wangensteen 1932) have been confirmed since by a number of investigations Holt (1934), Knight and Slome (1936, 1937) Aird (1937), and Maycock (1938) Observers had indicated repeatedly that strangulating obstructions are potentially more serious than simple obstructions Murphy and Vincent (1911) Wilkie (1913) Foster and Hausler (1924) Demonstration of the blood loss factor in strangulating obstructions has solved in part the mystery of this occurrence

Scott and Wangensteen (1932) studied the toxic effect of fluid collecting in the peritoneal cavities of dogs with strangulating obstructions in the following manner

Effect of Intravenous Injection of Peritoneal Fluid Attending Strangulating Obstruction

In fourteen dogs embracing the various types of interference with blood flow employed the peritoneal fluid was collected and infused into

and veins together were tied did not appear to make much difference, but when the veins alone were tied, a gradual, but definite and lethal fall in pressure occurred invariably Death followed ligature of the arteries alone or arteries and veins, to be sure, in 16 to 20 hours, but no significant change in blood pressure was observed until shortly before death Under the motive force of systolic blood pressure, blood was being forced into the gut wall and lumen of the bowel, the mesenteric vessels being end vessels and egress of the blood being prevented by ligature of the mesenteric veins hemorrhagic infarction of the gut occurred with considerable loss *of blood*

The contrast in gross appearance of the segments of gut, whose blood supply had been interfered with in these various manners was striking When the veins were tied, the resultant color of the bowel after 3 to 5 hours was a deep purple, and the segment was heavy and distended The wall was thick, the lumen of the bowel contained dark blood frequently clotted, and the peritoneal cavity contained considerable bloody fluid The segments in which the arteries alone or arteries and veins together had been tied, manifested similar findings These segments of gut were also purplish in color, but were not found to be distended and heavy as when the veins alone were interrupted The wall was thin and extremely friable, and in the larger number the bowel wall was perforated in one or more places The peritoneal cavity in such instances contained a dark foul smelling bloody fluid, when the segment was not perforated a small amount of blood tinged fluid was found In group four in which an encirclement ligature had been placed about the bowel findings intermediate between the two types just described were found Instances approximating the appearance of pure venous obstruction occurred and findings similar to those of pure arterial interruption were observed less frequently

In order to determine the degree of blood loss in each group, the peritoneal fluid was collected and its protein and hemoglobin content determined the weight of the segment was ascertained after excision and the amount of blood loss was calculated from hemoglobin determinations made upon the bowel content and peritoneal fluid The increases in weight of the segments of gut could be *fairly* accurately determined from a knowledge of expected weights of certain lengths of the normal gut at different levels described in a previous part of this study Hemoglobin determinations were made by the Sahli method The blood volume loss was calculated by taking the arbitrary figure of 7 5 per cent of the body weight as the total blood volume

The increase in gut weight in group one in which the veins were tied averaged 283 per cent In groups two and three in which the arteries and veins were tied, there was no increase in gut weight In group four, in which an encirclement ligature was placed about the bowel the increase in weight averaged 235 per cent In the latter group the loss in blood volume averaged 35 per cent, in vein ligations alone, the average blood loss was 55 per cent In the unruptured instances of ligature of arteries alone or together with the veins, the blood loss factor was not so great

recovered in the first aspiration made from the peritoneal cavity (45 minutes after the ligation of the veins) caused delayed convulsions which appeared in the frog one hour after injection All injections of subsequently aspirated fluid proved negative, however

The Bacteriology of the Peritoneal Fluid Accompanying Strangulating Obstruction

Scott (1938) studied the peritoneal fluid collecting in the peritoneal cavity in strangulating obstructions, in the following manner

In ten dogs encirclement ligatures of the lower ileum of segments of bowel about 3 feet in length were made At periods, varying from 3 to 4 5 hours later the abdomens of the dogs were reopened and specimens were obtained for bacteriological study The constricting tape was also removed Cultures were made on lactose liverpeptone and brain media Smears were then made from these cultures after 24 and 48 hours A large number of organisms including the following were found (1) Gram positive spore forming rods (2) Gram positive micrococci (3) Gram positive diplococci (4) Gram negative rods (5) *Clostridium Welchii* (6) *Bacillus coli* (7) *Bacillus aerogenes* (8) *Streptococcus hemolyticus* (9) Staphylococcus (10) Sarcina

In six of these ten cases positive cultures were obtained, four were negative There were also four deaths, three of the deaths occurred within two hours of the release of the encircling tape, and were undoubtedly due to continued hemorrhage into the gut One of the deaths occurred in an animal having negative cultures and three recoveries occurred in the group in which the cultures were positive These findings are in consonance with those recorded by a large number of investigators who have examined the fluid in the sac in strangulated hernias Bacteria may be present in the fluid even though the gut may survive, that the viability of the gut is threatened or impaired is apparent

There appears to be no cogent evidence in the contention of Williams (1926) that toxemia due to anerobic organisms plays an important role in the lethal issue of intestinal obstruction Haerem, Dack and Wilson (1938) failed to demonstrate B Welchii toxin in closed intestinal loops in dogs And McIver and his associates (1929) failed to observe any protective therapeutic value from administration of B Welchii antitoxin to obstructed cats Yet undoubtedly in the peritonitis attending late strangulating obstructions in patients anerobic organisms play an important role now and then

F THE TOXEMIA QUESTION AND BOWEL OBSTRUCTION

As related previously clarification of the mystery surrounding the cause of death attending high jejunal obstruction did much to lessen focus of attention upon the toxic absorption factor as the primary cause of death in obstruction Demonstration of the significance of the blood loss factor as an important item in the lethal issue of strangulating obstruction has served to detract also from the former attractiveness of the toxic absorption theory, in interpreting acceptably observed phe-

the leg vein of another normal dog A tracing of the carotid blood pressure of the recipient was obtained during and for some time following the injection These dogs were lightly anesthetized with ether during this interval

Results—A fall in pressure was obtained only in those instances in which the loops had ruptured Attending the injection of the peritoneal fluid from these dogs a sharp fall of arterial pressure followed All recipients died the following day In the remaining ten instances, no immediate or delayed effects attended the injection

Knight and Slome (1936) collected fluid from strangulated intestinal loops by placing a bag about the loop They were able to demonstrate, on intravenous injection, the presence of a toxic material, in this fluid Wahren (1936) and Aird (1937) made somewhat similar observations—their findings indicating too, the presence of a toxic material in the fluid collected in bags, placed about strangulated intestinal loops

Influence of Arterial and Vein Ligation on Absorption of Strychnine

In ten dogs in which the arterial supply to a segment of gut was interrupted by ligating the arteries, 50 milligrams of strychnine sulphate were introduced into the segment after both ends were tied to prevent absorption from the adjacent healthy bowel The average survival period was 16 7 hours None of the animals manifested symptoms of strychnine poisoning during life Samples of the peritoneal fluid (10 to 20 cubic centimeters) were injected into the peritoneal cavities of four guinea pigs None developed convulsions In three instances, 3 to 5 cubic centimeters of peritoneal fluid were injected into the dorsal lymph sac of three frogs all developed convulsions after 12, 15, and 45 minutes respectively Strychnine undoubtedly therefore had penetrated the bowel wall even though in small amounts It was interesting to observe how mere interruption of the arterial blood flow with the avenue for escape through the veins still open, practically does away with mesenteric absorption

Similar determinations were made upon nine dogs in which the veins to a segment of gut three feet in length were tied Fifty milligrams of strychnine sulphate were injected into each loop and the ends of the segment were tied to preclude absorption from the adjacent healthy bowel The average survival period was 8 hours This figure was made somewhat greater than that previously observed for various obstructions in that one dog survived for 20 hours The more usual survival period as indicated in the previous series in which the veins alone were tied was 4 to 6 hours Three of these nine dogs developed convulsions, in six dogs no evidence of strychnine absorption occurred The loss of blood alone into the infarcted segment is a prominent feature in the cause of death Peritoneal fluid was recovered in each instance and injected into the dorsal lymph sacs of frogs In the three animals which developed convulsions, the frog tests were positive In two of the nine dogs a catheter was placed into the cul de sac and aspirations of the peritoneal fluid were made every 30 to 45 minutes and injected immediately into frogs All of these injections proved negative in one frog, in the other, the fluid

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nomena attending obstruction, which demand explanation The recital of observations, which preceded, concerned itself largely with pointing out the importance of mechanical effects of increased luminal volume, pressure and tension upon the permeability and viability of the bowel wall It is this writer's belief that these are the important items that contribute to the lethal issue in bowel obstruction

There are, however, a number of recorded observations that bear upon the alleged factor of toxic absorption, which can not be passed over lightly In the analysis of *how* the toxic absorption occurred, to one accustomed to think *along the mechanistic lines, outlined above, the question recurs* always Was there injury of the bowel wall followed by transperitoneal migration of noxious substances?

It is obvious that discriminating data sufficiently precise to answer the query of *how* the toxic absorption occurred, are not always available It is perhaps fair to say that more and more, experimentalists and critical clinicians are leaning toward the mechanistic conception developed in this discussion Many have capitulated completely to this view Bottin (1938) appears to be one of the few, who has concerned himself with experimental aspects of the problem, who clings still to the toxin absorption idea, as constituting a satisfactory explanation for the lethal issue of obstruction

The demonstration of a fluid with toxic properties, collected in bags or from the peritoneal cavities of dogs with strangulated intestinal loops, has been made by a large number of investigators (Knight and Slome (1936, 1937) Wahren (1936), Aird (1937), Maycock (1938) and others) Maycock demonstrated the presence of histamine and choline in such fluid but believed that the circulatory depression attending strangulating obstructions was not explicable on the basis of absorption of toxic mate*rials from the peritoneal fluid, alone The blood loss factor, discussed at* length in the preceding section has been corroborated adequately by a number of investigators, and is, in many clinical obstructions, as well as in the experimental animal, an item of importance

Sweet, Peet and Hendrix (1916) went so far as to suggest that the only real hazard from a closed intestinal loop was perforation Undoubtedly, however, noxious agents can migrate through a devitalized bowel wall, before an actual anatomic break in continuity is apparent

It is proof of absorption from the lumen, via the mesentery, in simple obstruction that, those like myself demand who affect not to believe in the toxin absorption idea Chenut (1926) and Morton (1939) appear to compose the difficulties of the situation quite readily by stating that attending prolonged sustained increases of intraluminal pressure areas of necrosis develop in the mucosa of the bowel wall exposing capillary blood vessels, through which absorption may occur Death of the bowel wall from the mucosa to the peritoneum obviously would permit transperitoneal migration More detailed studies employing combinations of physiologic and histologic approaches are necessary to settle this question definitely The following questions appear to bear fairly directly on the issue 1) To what extent are the submucosa and the circular muscle, each responsible

of anaphylaxsis No evidence of anaphylaxsis was observed when un obstructed guinea pigs, sensitized to horse serum, were fed horse serum This evidence suggests definitely that abnormal absorption occurred, but whether by the mesenteric pedicle or by transperitoneal migration, as a result of injury to the intestinal wall, is not clear

It is conceded freely by everyone, and, there are a number of experimental observations which suggest that all intestinal content is toxic Hill and Stoner (1941) have pointed out that the leucopenia, attending intravenous injections of extracts prepared from normal or obstructed intestinal contents, may be employed as an agent to gauge the extent of the toxic reaction Any attack on the toxic absorption theory, which takes no account of the likely avenues of absorption, evades the most important aspect of the problem

The closed intestinal loop, employed first by Stone, Bernheim and Whipple (1913) to investigate the formation of toxic proteoses in bowel obstruction, has become an instrument of great value in demonstrating the damaging local effect of increased intraluminal tension And one of the startling conclusions, forced upon any one who becomes a student of the problem, is the surprising end effects of relatively low pressures, operating over a period of time

The local end effects, attending sustained increases of pressure in long loops in the presence of simple obstruction, may be summarized as follows

1 Increase in intraluminal content (gas and fluid)
2 Increased motor activity of the bowel
3 Distension and intestinal stasis
4 Thinning of the intestinal wall
5 Increases in intraluminal pressure
6 Decreased absorption from the intestinal lumen
7 Venous stasis in the bowel wall
8 Anoxemia
9 Impaired viability
10 Histologic evidence of local injury to the intestinal wall
11 Increased permeability
12 Migration of noxious substances through the damaged bowel wall
13 Toxemia from transperitoneal absorption

G SUMMARY OF THE EFFECTS OF OBSTRUCTION

It has been indicated by a brief review of the work of a period somewhat longer than the past decade that the seriousness of high intestinal obstructions is due essentially to the loss of electrolytes and fluid by vomiting, and that the liberal administration of saline solution neutralizes these ill effects and permits the animal to tolerate the obstruction for a considerably longer time In low obstructions on the contrary, the loss of fluid and electrolytes is not a prominent feature and saline replacement therapy is not of much value In the high obstructions, vomiting empties more readily the distended loops, in the low obstructions evacuation of the lower loops is not accomplished readily and the mechanical effects of distension upon the bowel wall become more manifest

The factors contributing to distension are (1) the alimentary digestive juices which, in adult man, are probably in excess of 7,000 cubic centimeters a day. Under the influence of distension and obstruction, the secretion of alimentary fluid may be increased in amount. (2) The chief source of gaseous distension is swallowed air. This was shown by excluding the swallowed air factor by transecting the cervical esophagus and inverting the distal end. Swallowed air accounts for about 68 per cent of the gas in obstruction of the small intestine, of the remaining 32 per cent, 70 per cent originates by diffusion from the blood into the bowel lumen, the remaining 30 per cent arises through putrefactive activity of intestinal bacteria. The liberal administration of saline solution to dogs with obstruction increases the amount of fluid in the bowel. In the presence of a gut which is dilated because of obstruction despite the exclusion of the swallowed air, gas may still find its way into the gut from the blood.

The composition of gases has been determined in a large variety of experimental and clinical types of obstruction. Nitrogen constitutes from 70 to 80 per cent of the gas present in obstruction. Hydrogen sulfide, the combustible gases (hydrogen and methane), the volatile basic group (ammonia and the tertiary amines), carbon dioxide and oxygen constitute the remainder in somewhat variable amounts.

The effects of acute obstruction upon the bowel have been studied and it was observed that the bowel shortens usually in established experimental obstructions, a shortening of 20 to 33 per cent was observed over considerable lengths proximal to the obstruction. When correction is made for this shortening process, an increase in weight of the obstructed bowel of 34 per cent over the normal was found. The bursting strength of obstructed segments of bowel is considerably reduced as compared with the normal (50 per cent).

The sustained intra enteric pressures were determined in a large number of experimental and clinical obstructions. The average sustained intra enteric pressure in dogs with low ileal obstruction was found to be less than 10 centimeters of water pressure. In four patients with obstruction of the small intestine, the sustained intra enteric pressure varied between 4 and 14 centimeters of water. In a number of colon obstructions in man, however, considerably higher intra enteric pressures varying between 12 and 52 centimeters of water were found. The competency of the ileocolic sphincter and valve makes of the colon a closed loop obstruction with the distinct handicap that in addition, the ileocecal valve permits fluid and gas to be poured in from the ileum but precludes regurgitation into the small intestine.

The effects of sustained pressures upon the anatomy, viability and permeability of the bowel were studied. Diffusion of potassium ferrocyanide through the bowel into the peritoneum did not occur as long as the gut wall was viable. Whereas an intra enteric pressure continuously sustained for 27 and 28 hours caused petechial hemorrhage in the bowel wall, it was still viable and not abnormally permeable. Similarly, an intra enteric pressure of 20 centimeters of water sustained for 10 and 22 hours caused congestion of the bowel, but it was still viable. Pressures of 20

centimeters maintained for 28 and 32 hours caused necrotic patches in the gut and the bowel was no longer viable and permitted the diffusion of *potassium ferrocyanide through its wall* Pressures of 40 centimeters of water were tolerated as long as 11 hours, but when longer continued, necrosis of the gut wall with abnormal transperitoneal diffusion occurred

The results of microscopic studies of the bowel wall in instances of *experimental simple* obstruction of 3 to 6 days' duration indicate that the congestion observed owes its presence to dilated blood vessels in the gut wall No evidence of interstitial hemorrhage was observed No areas of necrosis or mucosal ulceration were found The findings were limited to *edema, and shortening and clubbing of the villi*

In addition, the systemic effects of increased intra enteric pressure, described above, are not to be ignored Segregation of blood in the lower extremities occurs apparently with ensuant reductions in effective circulating blood volume

The effects of obstruction and distension upon absorption were studied An 18 inch loop of lower ileum absorbed, in an hour, 87 per cent of the water necessary to fill it, whereas in similar previously obstructed loops only 9 per cent was absorbed No evidence of histamine absorption was obtained from viable segments of obstructed bowel No toxic effect was obtained on transfusing the entire return flow of blood from the superior mesenteric vein of dogs exsanguinated in the terminal stages of simple obstruction into normal animals No depression of the arterial pressure was observed in the recipients In the event that histamine was absorbed from these obstructed segments of bowel, it was detoxified in going through the bowel wall, for slow injections of 0 83 milligrams of histamine dichloride per minute into a mesenteric vein caused a profound and protracted depression of blood pressure

Strychnine sulphate is absorbed somewhat more slowly from obstructed segments of bowel of the dog and cat (6 to 13 minutes) than from the normal (2 to 3 *minutes), placing loops in an extraperitoneal position* delays absorption slightly also (8 to 15 minutes) Devascularizing the intestinal loops into which the strychnine was placed delayed the appearance of convulsive phenomena for 8 to 15 hours When the intra enteric *pressure was tremendously increased in normally vascularized loops* no evidence of strychnine absorption was observed in viable loops until the intraluminal tension was reduced to 70 millimeters of mercury pressure When, however an intra enteric pressure of 100 millimeters of mercury *pressure was employed in* devascularized loops into which strychnine had been placed convulsions appeared in three hours indicating that transperitoneal diffusion had occurred

Lymphatic absorption of trypan blue and gentian violet is enhanced and accelerated by obstruction Increases of intra enteric pressure, of a grade that causes venous stasis augment absorption by the lymph vessels Obstruction of the bowel facilitates the absorption of bacteria into the mesenteric lymph nodes Bacillus pyocyaneus introduced into obstructed loops of cats were recovered from the mesenteric lymph nodes but not from the thoracic duct chyle Severance or ligature of the mesenteric

pedicle in obstructed cats, in order to obviate lymphatic absorption, did not increase the survival time

In a study of the effect of strangulation upon the bowel, it was found that the occlusion of veins permitted the loss of considerable blood into the wall and lumen of the strangulated segment When the veins alone were tied to a segment 3 to 4 feet in length enough blood was lost in 4 to 5 hours to produce shock and frequently death When the arteries and veins together or the arteries alone were tied the survival period was considerably longer (16 to 20 hours) and though fluid of a high protein content accumulated in the peritoneal cavity, the blood loss was not great Accompanying arterial ligature, there was no gain in weight of the gut, but when the veins alone were tied the average increase was 283 per cent and due largely to the leakage of blood into the gut wall and bowel lumen, in consequence of the venous obstruction

The fluid accumulating in the peritoneal cavity following interference with the blood supply of segments of bowel was found to be non toxic on intravenous injection into other dogs except when the segments were perforated Of ten dogs with encirclement obstruction bacteria were found in the peritoneal fluid in six instances Three of the e recovered after release of the constricting tape

When strychnine sulphate was placed in the gut following ligation of the arterial supply no evidence of strychnine ab orption occurred during the life of the animal which averaged 16 7 hours in ten dogs Injections of peritoneal fluid however into the dorsal lymph sac of frogs gave proof of diffusion of strychnine into the peritoneal cavity in a few instances In three of nine dogs in which the veins to a segment of bowel three feet in length were tied evidence of strychnine diffusion through the bowel wall was obtained in the occurrence of convulsions in the dogs and similar convulsive phenomena in frogs following dorsal lymph sac injections of samples of the peritoneal fluid The increase in tension in a non viable gut wall is responsible undoubtedly for accelerating the diffusion of strychnine through the bowel wall in this venous obstruction group as contrasted with its slow diffusion through the devitalized bowel wall of arterial obstruction

Conclusions—The results of these studies emphasize the significance of the mechanical factors in the development of the ill consequences of obstruction Apart from the loss of essential fluids which constitutes an important element in high obstructions alone the chief factor of concern is the viability of the bowel wall whether threatened by increase of intra enteric pressure or by external constricting agents The importance of swallowed air in initiating distension and its effects is demonstrated conclusively in the esophagostomy experiments on the dog described previously in which accretion of distension through this source is precluded Transperitoneal diffusion or absorption apparently occurs only through a bowel wall whose viability is seriously compromised When the bowel wall is viable all absorption from the gut except through the lymphatic channels is diminished by increased intra enteric pressure High intra enteric pressures which jeopardize the circulation of the bowel,

regularly attend acute clinical cases of obstruction of the colon in man *The sustained intra enteric pressures observed in obstruction of the small intestine of the dog and in clinical cases are not great, but of the order of magnitude of about 10 centimeters of sustained water pressure, which if long continued cause histological changes in the mucosa of the bowel* These relatively low pressures have their explanation in the ability of the bowel to accommodate itself to various grades of distension, without great alteration in intra enteric pressure, *made possible in the small* intestine by the participation in the distension of a considerable length of gut The lower segments of a long stretch of distended small intestine, cannot, however, escape the effects noted in closed loops, in the dog, in which sustained increases of intraluminal pressure are maintained

What Are the Probable Lethal Factors in Obstruction?

The papers of Cooper (1928) Morton (1939) and Besser (1940) should be consulted for a comprehensive discussion of the many factors involved *Though no direct and unequivocal answer has been obtained for this* very pertinent question, the results of this study permit formulation of the following propositions

Apart from the loss of fluids and electrolytes which are of serious consequence in high obstructions alone, the chief effects of obstruction are mechanical and concern intra enteric pressure as related to absorption and viability of the bowel Though it has been shown that intra enteric pressure increases normal lymphatic absorption, there is no evidence that abnormal lymphatic absorption occurs To be sure, dyes are absorbed when the bowel is obstructed, but *an important factor in their failure* of absorption normally is that, they do not remain long enough to permit of absorption Also, bacteria are absorbed through lymphatic channels under conditions of obstruction, but their presence has been demonstrated in mesenteric lymph nodes in the absence of obstruction But what is more important, neither bacteria nor dyes were recovered from the thoracic duct Every available evidence points toward a diminution of mesenteric venous absorption with increased intra enteric pressure Just how an edematous mucosa may affect mesenteric venous absorption is not wholly clear *Observations made on patients with high grade simple obstruction of* both the small intestine and colon, subsequently to be recited indicate that as long as the peritoneal coat of the gut is intact—that is, as long as the bowel is viable, transperitoneal absorption does not occur and the patient remains in good condition The results of this experimental inquiry are wholly in accord with those clinical observations and indicate that the chief lethal factor in simple obstruction is permeation of a gut wall whose viability has become impaired, by bacteria and other deadly agents In strangulating obstructions apart from the blood loss factor, this too is the chief concern It would in consequence appear that the rationale of well directed therapy should be reduction of intra enteric pressure by decompression or release of the obstructing agent before the viability of the bowel is impaired

In the judgment of the writer, the mechanistic conception of the ill

consequences of obstruction provides better interpretation and a more acceptable explanation, of the phenomena and end effects which attend bowel obstruction than does the toxic absorption theory

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PART II

GENERAL DIAGNOSTIC CONSIDERATIONS IN THE RECOGNITION OF BOWEL OBSTRUCTION

CHAPTER II

DIAGNOSIS IN ACUTE ABDOMINAL DISORDERS

A THE MAKING OF A DIAGNOSIS

EXPLORATORY laparotomy has been long in many hands, a favorite and frequent means of establishing the diagnosis in acute abdominal lesions So general has this practice become that operations for "acute abdomen" have been the order of the day "Acute abdomen" and necessity for operative intervention have been regarded commonly as synonymous Such a dictum served to lend the impression that many of the pre-operative deliberations concerning the probable nature of the lesion present were purely philosophic exercises of but little practical value A natural consequence of this appraisal contributed also to the feeling that the corrective measures employed by the surgeon were responsible largely for the patient's recovery And if the patient died, it was because of the nature of his illness The fallacy of such logic is not difficult to detect Nevertheless, *the unwary surgeon as well as the physician who deals with disease* and its vagaries are very likely to fall into this pitfall Rationalization on inadequate or incomplete data is predestined to lead to erroneous conclusions

Features of bowel obstruction (employing the term obstruction in the broad sense of intestinal stasis) are related so intimately to many acute abdominal diseases that it would appear proper to discuss here in a general way the diagnostic measures which are of value in the formulation of an opinion in acute abdominal disorders

The making of a diagnosis embraces essentially two items (1) the taking of evidence and (2) the interpretation of that evidence The sources for evidence are three in number (1) the history, (2) the physical examination, and (3) laboratory data All are important In an uncomplicated duodenal ulcer the factual data most valuable for the final decision are obtained from the history and the laboratory information particularly the x ray observations The physical examination in this disorder reveals frequently no tell tale signs In acute abdominal lesions very significant data are obtained almost invariably from the physical examination Incomplete history taking and perfunctory physical examinations are to be avoided studiously in every case Laboratory aids are of great worth in the solution of many diagnostic problems, but extremely few diagnoses however, can be made with their aid alone

In order to take evidence well it is necessary that the examiner know well the course or the natural history of the disease under scrutiny In addition he must know the various diseases which may give rise to a train of symptoms or a group of findings similar to the entity which is believed to be present Armed with this knowledge and mindful of the importance of method and possessed of the requisite experience to pass a mature opinion upon the evidence, the examiner will, in most instances arrive at a fairly accurate judgment So often in clinical medicine the case under consideration does not readily fit any of the classic descriptions of typical disease entities In such instances judicious weighing and sifting of evidence are of paramount importance The determination of what the salient features in the case are and their final integration, in the manner which will adequately account for the clinical picture and at the same time satisfy the opinion arrived at are exercises involved in every diagnosis In the taking of evidence, the keynote of success is *knowledge* coupled with the virtue of *method* in the interpretation of the evidence the wisdom which comes from *experience* when founded on the rock of adequate *orientation,* is sovereign

In the making of any diagnosis the examiner will do well to put to him self the three following questions if satisfactory answers can be secured to the first two, a fairly reliable answer for the final and most important one will probably be reached also (1) What is the functional disturbance present? (2) What is the anatomy of the lesion? (3) What is its pathological nature?

B THE HISTORY

There are times when a patient with an acute abdominal lesion is so ill that the examiner can not with good grace and a clear conscience ply the patient with questions until relief from his distress has been obtained If a reliable informant is available the pertinent facts may be obtained from him if not a careful examination of the abdominal findings should be made after which the patient's distress may be safely assuaged with morphine The danger lurking in securing relief from distress with opiates before the physical findings have been noted is apparent and has been emphasized abundantly In the instance of children the information must come second hand frequently and in infants regrettably the history is but an interpretation of what the parents or nurse observed

In the main the patient's complaint is the best lead to follow out in ascertaining the nature of an illness Not every patient with a complaint has a demonstrable disorder and in an occasional instance the complaint may not be related directly to the illness which final adjudication decrees to be present It is the responsibility of the examiner to determine which complaints are real which may be fancied and which are merely accessory to the disorder

The matter of first importance is to learn when the patient became sick In almost every acute abdominal disorder the patient can state definitely the day and hour when his indisposition began It is significant to know what the first symptom was and whether it has continued to be the main complaint In most acute ills of the abdomen, pain is the first and pre

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Chills accompanying abdominal pain indicate the presence of an infection and are most frequently observed in the cholangitis of biliary tract infection and pyelonephritis Their occurrence in pneumonia in which abdominal pain may be concomitantly present or in appendicitis with thrombosis of the mesenteriolum of the appendix are well known

Whether there have been antecedent similar attacks of pain should be learned, as well as whether there has been any previous indisposition owing to lesser disability Whether the distress has had any uniform time relation to ingestion of food, if eating relieves or aggravates the distress Whether the patient feels better on an empty or full stomach or when there is some food in it whether the distress comes shortly after eating or only after an hour or two These inquiries help to orient the examiner in the nature of the illness Flatulence and distress shortly after eating are common accompaniments of biliary tract disease The mechanism of this occurrence is not understood well The distress of ulcer is usually relieved by the intake of food A patient who has complained of occasional twinges of pain which he has interpreted as gas pains, and, who states that his abdomen is noisy frequently and that, he can feel elevations upon his abdominal wall now and then, at the time of gas pains—such a patient is likely to have a stricture in the bowel

Nausea and Vomiting

Nausea and vomiting attend acute abdominal disorders frequently and appear early usually The occurrence of vomiting in itself is therefore of no great consequence Its relation to other elements of the story, however, when properly integrated, gives useful information The features of vomiting and the character of the vomitus are to be determined carefully Frequent and copious vomiting speaks for gastric and intestinal stasis If the vomitus be of a brownish yellow color or feculent and crampy intermittent pain is present also it is almost certain that the patient has mechanical obstruction of the bowel and in all likelihood, of the small intestine As has been pointed out already (page 30) in obstruction of the colon vomiting is frequently absent altogether and there is no gastric retention usually as determined by the duodenal tube Vomiting accompanied by fairly complete relief of distress is suggestive of gastric retention due to pyloric obstruction However, curiously enough, pyloric obstruction does not give rise to true pain as do obstructions anywhere else in the intestinal canal Neither does the patient with obstruction to the efferent loop, after gastrojejunostomy or gastric resection, exhibit evidence of intestinal colic In this instance the reason is apparent It is not the afferent loop but the stomach in which the retention occurs largely—the stomach being very dilatable nausea and vomiting occur usually before the pain attending muscle stretch, becomes evident The patient with regurgitant vomiting occasioned by obstruction of the small bowel feels better usually after evacuation of the stomach but the crampy pain owing to the obstruction continues The patient with reflex vomiting occasioned by appendical biliary, or renal colic experiences no relief after vomiting usually The vomiting early in obstruction may be reflex in

dominant symptom throughout. Now and then, however, as in appendicitis there may be anorexia or an indeterminate indisposition of a few hours' duration before pain begins. When the illness has its origin at night and the patient has gone to bed feeling well, pain is the invariable first complaint except in those disasters where hemorrhage is the underlying fault.

Pain

The character, location, constancy, and radiation, if any, of pain are all significant. Whether tenderness accompanied the pain and was immediately apparent or only came later, as well as its extent, must be inquired into. The disability caused by the pain and whether the incapacity was great and immediate or has increased since the onset are important to determine. What the patient did, if anything, to seek relief from his distress, whether he continued to work, went to bed, walked the floor, rolled about or lay prostrate and anxiously quiet, when the malady seized him, tell the examiner much about the nature of the disorder.

Appendical, bowel, biliary, and renal obstructions give rise to an intermittent crampy pain. *The acme of the colic is of variable duration, lasting* usually for several seconds to a few minutes. In lesions that assume the character of an inflammation with the elapse of time, there is usually as well a constant distress between the colics. The distresses occasioned by the various acute abdominal ills do not lend themselves well to comparison. The most agonizing type of pain is probably observed in perforation of an ulcer of the stomach or duodenum, the pain of pancreatic necrosis approaches that of perforation in severity. Both of these afflictions give rise to a constant type of distress, often so severe that its sufferer can not adequately describe it. The discomfort provoked by biliary or renal colic probably comes next in order of intensity. The nature of the pain in bowel *obstruction is familiar to all who have suffered intestinal colic from what*ever cause, and is described usually by the patient as a gas pain. In strangulating obstructions because of the concomitant peritoneal irritation, there is pain also between the seizures of intestinal colic, which does not let up. A dissecting aneurysm of the aorta may cause severe abdominal pain. Simultaneous pain in the lower extremities, because of an inadequate blood flow or diminished or absent pulsations in their vessels, helps to identify the nature of the catastrophe.

All colics, having their origin from an intraperitoneal viscus, may be referred to the mid abdomen. The kidney, which develops from a lateral *anlage*, is characterized usually by pain in the flank from the start. *Shoulder pain in intraperitoneal lesions* signifies irritation of the diaphragm. In perforation of the stomach, it may occur early; in a strangulated ovarian cyst it usually occurs after the colic has ceased and signals the escape of considerable sanguineous fluid into the peritoneal cavity. Biliary and renal colics apparently are the only acute abdominal afflictions which commonly have typical pain radiations. In biliary colic it is into the back at a spot below *the tip of the scapula and to the right of the* spine; in renal colic, it is into the corresponding groin and, in males, frequently complain of pain in the right testis.

suggest the necessity of a careful examination to see whether evidences of pregnancy are present When inspection of the cervix and vaginal walls and palpation fail to give decisive information, the Ascheim Zondek or the Friedmann tests for pregnancy should be made The frequency of painful cramps attending menstruation constitutes a deterrent to attaching the same significance to low abdominal pain in women as in men In consequence, the warning of pain in acute afflictions of the lower abdomen is more likely to go unheeded in women

C THE PHYSICAL EXAMINATION

The criteria of value in the physical examination of the patient with an acute abdominal lesion are the same measures found useful in the recognition of diseases in other parts of the body These are inspection, palpation percussion and auscultation In addition digital examination of the rectum and vagina frequently afford helpful information

General Condition

Ascertainment of the general status of the patient with an acute abdominal disorder is often the matter of first concern and demands inquiry frequently before the details of the story are elicited The patient's general appearance the state of his nutrition, his countenance and the expression of the eye, the color moisture warmth, and turgor of his skin, the quality of the pulse and the character of the respiration are significant matters which serve to orient quickly the seasoned examiner concerning the general condition of the patient The necessity for a general examination embracing careful scrutiny of the heart and lungs the blood vessels including determination of the blood pressure, the superficial lymphatic system, the extremities and back the body orifices, and a test of the reflexes and sensation are quite obvious These investigations must be made as incidents in the physical examination by all practitioners of medicine who essay to pass on the general status of patients There is great danger in the special examination when its findings are not related to the examination of the patient as a whole

A composed face affords the examiner considerable reassurance Still behind the mask of a stoic mien much may be hidden The agony of the patient with severe abdominal pain is usually evident upon his face The wrinkled and furrowed brow tense features and drawn lips which may conceal clenched teeth speak as plainly as an inner voice A pallid face with beads of perspiration lend involuntary confirmation of the patient's distress Periodic tranquil relaxation informs the examiner that the pain is intermittent and colicky in nature

The Temperature

Only distinctly bacterial invasions as occur in inflammatory afflictions such as salpingitis of the Fallopian tubes and pyelonephritis are accompanied by definite and consistent early fever After the elapse of time and contingent upon how the local disturbance (frequently obstruction as in acute biliary renal, or appendical colic) has favored the occurrence of

nature too, but then it has the character of gastric or bilious vomit It is the occurrence of stercoraceous vomit which attaches special significance to the presence of crampy abdominal pain Experience with the employment of suction applied to an inlying duodenal tube has taught that vomiting after abdominal operations is due essentially to retention in the *stomach and upper reaches of the intestinal canal* Keeping the stomach and duodenum empty by continuous suction renders the occurrence of such postoperative vomiting very unusual

Urination

Whether there has been abnormal frequency of micturition and whether it has been painful must always be inquired A cul de sac abscess or inflammatory process in the vicinity of the urinary bladder may give rise to frequent urination The painful features of the frequency as occur quite regularly in urethral vesical, or ureteral lesions, however, are often absent when the irritation is provoked by lesions extrinsic to the urinary tract The occurrence of hematuria is of particular localizing value Save for the unusual case of hematuria occasioned by an inflammatory lesion in juxtaposition to the ureter or bladder, gross blood in the urine identifies the lesion as being present in the urinary tract In suppuration of the appendix overlying the ureter, hematuria, from extra urinary tract lesions, has its most frequent cause among acute abdominal disorders

The Bowels

Diarrhea is provoked more often by the self administered remedies employed for the relief of distress in acute abdominal disorders than by the disorder itself It occurs particularly in instances of enterocolitis, which condition, because of the occurrence of *intestinal colic,* may simulate mechanical bowel obstruction Occasionally diarrhea is observed in appendicitis More commonly in acute abdominal conditions there is obstipation of some degree Accompanying the intestinal stasis which is common to many acute lesions, distension occurs, and the giving of an enema to try to evacuate the bowel is not an uncommon first home remedy It is always well to inquire whether cathartics or enemas have been administered Both are pernicious practices In a tubal pregnancy a hematoma in juxtaposition to the pelvic colon may give rise to pain on defecation An experienced nurse suggests not uncommonly the presence of a cul de sac abscess when during convalescence after an operation for suppurative appendicitis, a febrile patient feels a frequent urge to empty the bowel and only mucus comes away

Menstruation

Whether any menstrual irregularity of time or flow is present, it is particularly important to know in all painful afflictions of the lower abdomen in women The possibility *of ectopic pregnancy in women of child* bearing age must always be kept in mind The premature or delayed occurrence of menstruation, commencement cessation and recurrence of menstrual bleeding, as *well as scant or excessive flow, are significant* and

in the pelvis over the course of the ilio psoas muscle, as in a large perinephric abscess occasions the patient to lie not infrequently with the thigh of the corresponding side acutely flexed at the hip joint, the knee is also maintained flexed to support the thigh in that position In the main inspection of the abdomen is not of the same significance in the recognition of acute abdominal disorders as it is in abdominal swellings or tumors which accompany acute lesions only occasionally The most valuable evidence obtained from inspection concerns the presence of both components of respiration In disorders which effect an intense rigidity of the abdominal muscles, the diaphragmatic component of respiration may be ablated completely In such instances the breathing is frequently entirely thoracic in character In the lesser splinting of the abdominal muscles attending lesser grades of abdominal rigidity no visual evidence of disturbed respiration is observed usually although it may be noted that the frequency of respiratory excursions may be quickened while their depth is decreased

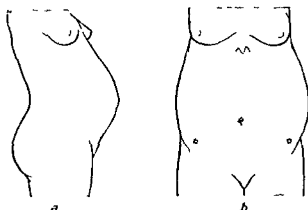


Fig 16—The contour of the abdomen in intraperitoneal tumor and ascites (a) A large intraperitoneal tumor causes protuberance of the anterior abdominal wall (b) In ascites the abdomen is broad due to the collection of fluid in the flanks (*Practitioners Library of Medicine and Surgery* D Appleton Co 4 -08 1934)

Inasmuch as the accumulation of fluid in the peritoneal cavity comes into question not infrequently even in acute abdominal disorders it is well to speak of it here In a patient whose abdomen is enlarged from either the presence of free fluid (ascites) or an intraperitoneal tumor such as a cyst or solid tumor inspection furnishes frequently the best evidence in this differentiation Instances have come to the writer s attention in which the diagnosis of ascites has been made as the cause of abdominal enlargement after thorough examination and study when careful inspection alone serves to indicate either that the fluid was encysted or that a solid tumor was present Ascites gives a broad abdomen which bulges in the flanks A large cyst or tumor protrudes the anterior abdominal wall In the adipose abdomen of a corpulent individual this difference may be difficult to detect The most striking illustration of this contrast is afforded by the prominent protuberance of the nulliparous pregnant abdomen near term when compared with the broad abdomen with bulging flanks of the patient with marked ascites from cardiac failure (Fig 16) Tenting of the anterior abdominal wall is a fairly reliable sign of a large pancreatic cyst

An intraperitoneal tumor which lies in the upper abdomen the outline

infection or upset the general bodily functions, fever is usual in most acute abdominal disorders A temperature of 104° F, occurring early at the onset of an illness whose origin would appear to be in the abdomen, should cause the examiner to suspect the lung or the kidney If chills have occurred, the bacterial origin of the disorder is certain and bacteria have, in all likelihood, found their way into the blood stream

The Pulse

In acute abdominal disorders generally, apart from those conditions in which considerable hemorrhage occurs, the pulse is not much altered Unfortunately, unwarranted zeal for graphic description of a picture has, now and then, occasioned observers to give more attention to the form of their description than to careful observation of what they noted at the bedside And the more it is to be regretted that it is these graphic descriptions frequently which find their way into textbooks When writers of texts will cease to copy these oft repeated errors and confine themselves to matters of their own knowledge and experience, many of these barnacles will be deleted from our surgical texts In the experience of the writer, even such a tragic occurrence as an acute perforation of a duodenal ulcer is not accompanied by material quickening of the pulse Later, in the course of every acute abdominal disorder, the behavior of the pulse is gauged by the general effects of the lesion upon the body economy Peritonitis, accompanied by an increased permeability of the vascular bed, causes hurrying of the pulse invariably

The Blood Pressure

The profound prostration which may attend a catastrophic abdominal disorder may lend the impression that shock is present As with the pulse, it may be said, here too, that depression of the arterial blood pressure, without which true shock does not occur, is not seen early in acute abdominal ills, unless hemorrhage is present In perforated ulcer, the pulse, blood pressure, leucocyte count, and temperature remain usually within a range bordering on the normal for a period of several hours On the whole, quickening of the pulse is present usually before blood pressure falls are in evidence A very rapid pulse is followed almost invariably by a blood pressure which tends to fall to the shock level

The Examination of the Abdomen

Inspection—The abdomen is best inspected in the presence of good light—the patient lying supine, while the examiner looks across the abdomen toward the light The attitude of the patient in bed frequently yields valuable information The patient who complains of colic not uncommonly writhes about, finding it difficult to lie still, the patient whose parietal peritoneum has been irritated by the escape of content from the upper intestinal canal, by exudate from an inflammatory focus or by intraperitoneal hemorrhage lies very still usually and anxiously avoids any movements because it aggravates the distress Accumulation of pus

insinuated to a greater depth, then the hand is withdrawn quickly If there be any irritation of the parietal peritoneum over any extent, twinges of pain will be complained of and tenderness elicited This is the most delicate and reliable test of the presence or absence of peritoneal irritation Before concluding that peritoneal irritation is not present this maneuver (choc en retour) should be repeated in all quadrants of the abdomen Frequently a patient with acute appendicitis will indicate when this test is made in the left lower quadrant that quick release of the hand causes pain over the site of his spontaneous pain on the right side

Having ascertained the presence of signs of peritoneal irritability, one next proceeds to determine where the greatest degree of rigidity is This evidence gives more information concerning the probable site of the source of peritoneal irritation than any other criterion of physical examination Our entire formulary of physical diagnosis as it relates to the recognition of acute abdominal lesions, is pyramided upon the significance of muscle spasm and rigidity as the signs of greatest worth in the localization of the irritating peritoneal focus The examiner then interprets the rigidity in terms of the organs which lie beneath Not infrequently the skin is found to be hypersensitive over the area of greatest tenderness and rigidity Gentle brushing of the lanugo hairs may produce an uncomfortable sensation Pinching of the skin with the finger may produce pain and hyperesthesia may be demonstrated occasionally with cotton or pin prick

The most profound rigidity of the abdominal muscles observed clinically attends perforation of an ulcer of the stomach or duodenum The escaped contents of the stomach are extremely irritating to the parietal peritoneum However dangerous escape of the contents of the lower reaches of the colon into the peritoneal cavity may be this occurrence is not heralded by the dramatic and excruciating pain of ulcer perforation nor by the same board like contraction of the abdominal muscles which accompanies the leakage of gastric juice into the peritoneum It may be laid down as a rule that rigidity or muscle contraction response is a measure of the quality or severity of the irritant Intense board like rigidity of the abdominal muscles is synonymous with perforation of the upper reaches of the gastro-intestinal canal Lesser grades of rigidity are observed following the escape of fluid into the peritoneal cavity which attends pancreatic necrosis Pus bile feces blood and urine cause corresponding lesser rigidities of the abdominal wall

Cases have been brought to the writer s attention of patients who died of peritonitis several days following intraperitoneal rupture of the urinary bladder in which instances, it was alleged no findings were present during life to indicate that there was any irritation of the parietal peritoneum If the examination of the abdomen be carried out in the manner described at the beginning of this caption on palpation it is the writer s firm conviction that the sudden abnormal appearance of any fluid in the peritoneal cavity would give rise to increased irritability of the peritoneum which would be detected Ascitic abdomens to be certain are usually not tender However when ascites makes its appearance suddenly tenderness is present frequently The writer has observed instances of carcinoma of the

of which can be distinguished in part by inspection, is observed to move downward with respiration, if the tumor is freely movable, this range of motion may be quite wide. Retroperitoneal tumors, as of the kidney, not lying beneath the dome of the diaphragm, are not influenced so much by its respiratory excursions. Whether a tumor, whose contour may be visualized through the abdominal wall, is in the peritoneal cavity or in the abdominal wall itself (a rare but an occasional occurrence) may be determined readily in the following manner. The patient is asked to contract his abdominal muscles by blowing, with the mouth closed and the nose held pinched; if the tumor is in the peritoneal cavity, it disappears from view, a tumor in the abdominal wall is made more prominent by this maneuver (Bailey's sign). These observations with relation to tumors as determined by inspection should be corroborated always by palpation.

Visible peristalsis can be made out often, but as will be related subsequently (p. 111) this phenomenon is essentially a sign of muscle hypertrophy and accompanies obstructions which have been present for some time. By the same token, visualization of coils of intestine through an abdominal wall of average thickness indicates an obstruction that has been developing gradually. Almost invariably, a story of previous obstructive features can be elicited in such a case, even though at the time of examination, the obstruction may appear to be of recent origin. The writer has observed visible and palpable peristalsis in three patients with spastic obstruction when no actual organic obstruction was found at operation. The block to intestinal continuity engendered by the existing neuromuscular imbalance in the gut wall had undoubtedly in these instances been responsible for the hypertrophy of the muscle of the bowel wall.

Careful inspection of the common external hernial orifices (umbilical, incisional, inguinal and femoral) should be made in every patient who complains of abdominal pain. Infarcted fat, arrested in an umbilical or femoral hernial orifice, presents occasionally as an indurated redness of the skin and may be mistaken for a subcutaneous inflammatory process.

Palpation.—The most valuable criterion of physical examination in acute abdominal disorders as a whole is palpation. In the approach to this portion of the examination, it is important, in so far as such an attitude can be assumed by an ill patient, to have him in a position of repose. It is important that the patient's eyes are closed so that he can not follow or anticipate the movements of the examiner's hand. This precaution and gentle examination are the best means of excluding voluntary rigidity. The mouth should be open, the arms should lie relaxed at the sides, the legs are to be flexed slightly and the knees separated fairly widely and it is well to have a pillow beneath the knees to support them. If pain or tenderness is complained of in only one portion of the abdomen, it is well to commence the examination in the opposite quadrant. The examining hand (which must never be cold) is placed gently upon the abdominal wall and mild pressure is exerted. If no tenderness is encountered, as is indicated by absence of a tightening of the abdominal muscles beneath the palpating hand and a composed facial expression, the following examination should be made. The hand is again pressed gently upon the abdominal wall but

tured in the lateral position so that the right side is up, the correct manner in which to make this examination it is evident that gaseous distension of the proximal colon may also produce tympany over the otherwise dull liver The presence of free gas in the peritoneal cavity, even in small amount, can be detected by careful x ray examination and is a method to be employed regularly where a break in the continuity of the intestinal canal is suspected Percussion is of real value in distinguishing ascites from cysts or tumors of the abdomen, all of which are dull on percussion The movement of large collections of free fluid in the peritoneal cavity on change of posture can be demonstrated readily by the shifting of the dull areas Because the lateral recesses and the pelvis are the lowest places in the peritoneal cavity when the patient lies supine free fluid accumulates at these sites When the patient is placed in the left or right lateral position, the fluid will gravitate toward the side that is down and tympany may now be demonstrated over the flank that is up where dullness was present before (Fig 17) A full urinary bladder may be recognized in the presence of persistent dullness over the symphysis despite the change of posture Employment of the urethral catheter will confirm the suspicion

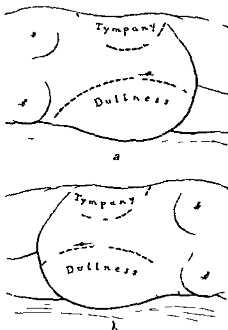


Fig 17—Shifting dullness in the presence of free peritoneal fluid (a) Right side down (b) Right side up

Auscultation—The chief value of auscultation in acute abdominal lesions relates to determination of whether *intestinal colic* is absent or present The repeated audition of borborygmi with the stethoscope at the acme of the pain of which the patient complains establishes the *pain* as being caused by intestinal contraction To be certain borborygmi or intestinal noises may be heard in other disorders but it is the intimate time relationship between noise and pain which identifies its *origin* A noisy abdomen does not therefore indicate the presence of a mechanical obstruction of the bowel such a finding denotes only the state of activity of the intestine A silent abdomen indicates absence of *peristaltic activity* a noisy abdomen without *intestinal colic* signifies that the bowel is hyperactive

In peritonitis when distension is great and fluid separates intestinal coils the heart sounds and occasionally even the breath sounds may be heard everywhere over the abdomen (Peters) The rationale is that fluid is an excellent transmitter of sound In mechanical bowel obstruction, with the collection of considerable fluid in the intestinal coils, this phenomenon

gallbladder as well as of the ovary in which the sudden appearance of fluid in the abdomen, gave rise to a picture simulating that of an acute inflammatory disorder

Another factor which must be reckoned with in interpreting the probable nature of the irritant is the time factor When, in response to the presence of the excitant, the serosal cells of the peritoneum have had an opportunity to dilute the irritant, the rigidity lessens When a patient suspected of having perforation of a duodenal ulcer is examined several hours after the occurrence of the disaster, board like rigidity may be absent altogether Occasionally even as great rigidity may be noted in the right lower quad rant as over the outlet of the stomach Did not the examiner bear in mind the significance of the immediate and great disability which characterized the onset, he might be misled into believing that the appendix was the source of difficulty This occurrence has its explanation in this, that after the elapse of some hours attending perforation of an ulcer in the region of the gastric outlet more fluid may have accumulated in the lateral drainage gutter opposite the appendix than near the pylorus

The parietal peritoneum is probably the most sensitive of all the serous membranes One need only consider the injection of air into the various body cavities and spaces to appreciate the verity of this statement The introduction of air into the pleural cavity or into the subarachnoid space of the spinal canal does not provoke usually any particular distress Pneumothorax may be done on ambulatory patients Pneumoperitoneum is decidedly a procedure for hospital practice alone Anyone who doubts the greater sensitivity of the parietal peritoneum may have his skepticism undone by reading an account reported some years ago by Armitage Whitman following a personal experience with pneumoperitoneum He had his own peritoneal cavity inflated with air to demonstrate more effectually to his confreres who he felt used this procedure more than they were justified, the incapacity which it caused When Whitman at tempted to go home he found it more comfortable to walk on his hands and knees or to stand on his head, so the air would gravitate up against the less sensitive pelvic peritoneum In the erect posture, shoulder pain was extreme Clinicians know well that the diaphragmatic peritoneum appears to be the most sensitive portion of the parietal peritoneum

Rigidity of the abdominal muscles in the absence of tenderness speaks for nerve root irritation such as may be excited by tabes dorsalis or a lesion of the spinal cord and demands a careful neurological inquiry by the examiner

Percussion —It is to be remembered that the thorax and abdomen would be dull on percussion were it not for the presence of air in the lungs or of gas in the bowel Percussion will detect readily whether enlargement of the abdomen is due to gaseous distension It can not be relied upon to deter mine whether the tympany is caused by general distension of the gastro intestinal tract or by a more localized gaseous distension This differ entiation must be left to x ray examination Neither is percussion to be depended upon to identify obliteration of liver dullness which may attend escape of gas in perforations of the intestinal canal With the patient pos

ing finger is to be noted particularly When pelvic masses are encountered, it is to be noted especially whether they are tender An enlarged uterus or an ovarian cyst may be present, wholly apart from the concurrent acute disorder In *intestinal colic,* the finding of an independent tender pelvic mass is suggestive of a strangulated loop of bowel Intrinsic tumor masses of the rectum are usually readily identified by this examination

The simultaneous digital examination of vagina and rectum is useful particularly in the determination of the nature of masses encountered in the pelvis behind the cervix The examination of these orifices combined with palpation of the lower abdomen with the free hand is particularly useful Frequently a mass in the lower abdomen, such as an enteric intussusception or a tumor of the pelvic colon can be brought within the reach of the finger of one of the two examining hands in this manner

D SPECIAL EXAMINATIONS

Gastric Intubation

In the same manner that the character of the vomitus may constitute an important clue as to the nature of the disease which causes it, so similarly valuable information is gained frequently by gastric intubation In reflex vomiting retention is rarely great, accompanying paresis of high grade in peritonitis stercoraceous material in considerable amount may be evacuated, in acute obstructions of the colon, the stomach is usually found empty or only gastric mucus or air, are obtained on aspiration Whereas in mechanical obstruction of the small intestine yellowish brown fluid is recovered whenever the obstruction has progressed far enough to be identi fied unless the stomach has just been emptied by vomiting It is extraordi narily important therefore for purposes of orientation, to collect the materials aspirated from the stomach with a suction device in a colorless bottle to permit accurate determination of its character

Enemas

Employment of enemas for diagnostic and therapeutic purposes is an old tradition In bowel obstruction the expulsion of gas or feces with an administered enema has been interpreted often as militating against the pre ence of obstruction It is not to be forgotten that the bowel distal to the obstruction is not only anatomically but also, usually physiologically normal Elsewhere Goehl and the writer have discus ed this matter at some length In the main it may be said that in incomplete obstructions particularly deceptive information will be obtained if one is guided by the premise that obstipation is complete in obstructions In paralytic or inhibitive types of ileus enemas are frequently ineffectual (Fig 10) Furthermore apart from simple mechanical obstructions of the small in testine the administration of enemas for diagnostic or therapeutic purposes in acute abdominal lesions should be discouraged strongly In intra peritoneal suppuration the use of enemas is contraindicated Several instances have come to the writer s attention in which exten ion of a localized or localizing inflammatory process attended the administration

may be observed also The concomitant presence of intestinal colic serves to identify its cause

Rectal and Vaginal Examination

The natural orifices of the body permit of examination of the organs of the pelvic cavity, which could not otherwise be satisfactorily made Similarly, in an incisional or para umbilical hernia with a large defect, exploration of the peritoneal cavity is possible frequently within the radius of the finger, aided by pressure of the fingers of the other hand upon the abdominal wall, which maneuver may help to extend the range of the palpating finger In every acute condition of the abdomen, irrespective of the age of the patient, digital examination of the rectum should be done The value of the information which may be obtained through it can be fully appreciated only when one is called upon to examine a male patient for an acute abdominal lesion, who has previously had extirpation of the rectum because of malignancy Vaginal examination is to be done in the instance of every married woman who presents herself because of an acute abdominal disorder In younger women and children, this examination may be omitted unless satisfactory information can not be obtained by digital examination of the rectum, in any instance in which the findings on rectal examination suggest the necessity for digital exploration of the vagina it should be done

In the main, the evidence obtained by the examination concerns the absence or presence of tenderness of the pelvic peritoneum and abnormal pelvic masses In instances in which appendicitis is suspected, tenderness is to be sought and if found compared on the two lateral aspects of the pelvis The absence or presence of pelvic tenderness as shown by such examination is valuable particularly in differentiating extra abdominal conditions, such as pneumonia with an accompanying pleuritis, which may give rise to tenderness and rigidity of the abdominal muscles from an intra peritoneal lesion The pelvic peritoneum will not be found tender in pneumonia It is to be remembered however in lesions of the upper abdomen such as acute cholecystitis or pancreatic necrosis that the pelvic peritoneum on rectal examination may also be found not to be tender

In the female tenderness elicited on movement of the cervix is to be interpreted as an irritative process in juxtaposition to the uterus Adnexal inflammation is the most frequent cause though a tubal pregnancy as well as an appendical abscess may also provoke this finding A stone lodged in the intramural portion of the ureter can frequently be felt on vaginal examination as can as well an infiltrative lesion (malignancy) of the base of the bladder In the male the condition of the prostate and seminal vesicles is to be noted on digital examination of the rectum Occasionally an acute seminal vesiculitis, a complication of gonorrhea may be interpreted as appendicitis if this observation is not made carefully The absence or presence of cul de sac implants, representing remote extensions of an intraperitoneal malignancy should always be noted An intussusception in an infant may be palpated not infrequently by digital examination of the rectum The presence of blood or mucus on the glove of the examin

The Blood

A leucocyte count is made universally as an emergency measure in every acute abdominal affliction Hemoglobin estimation, red and white cell counts, and a study of a blood smear are desirable in any diagnostic problem Leucocytosis may be looked upon as a reaction of the bone marrow to infection and injurious influences A physiological increase in the number of white blood cells accompanies digestion The total leucocyte count is interpreted usually as indicative of the resistance of the body to infection The latter count takes cognizance of the fact that immature cells in a blood smear are considered a measure of the severity of the infection The Schilling hemogram in which the neutrophils are further classified into segmented (mature) forms stab cells, and juvenile cells and myelocytes gives an even more accurate index of the severity of the infection The latter count takes cognizance of the fact that immature cell forms are common in the circulating blood in the presence of infection

Unfortunately no known means will differentiate absolutely infection from other occurrences which may simulate it Occasionally leucocytosis may be absent altogether in infection and leucocyto is is usual following trauma after hemorrhage and processes which cause severe dehydration The blood counts must be integrated into the clinical picture like any other isolated bit of evidence No therapeutic measure should be withheld or instituted solely on what the blood findings are In typhoid fever and influenza leucopenia is usual The rate of sedimentation of erythrocytes is too variable to be of much help in differential diagnosis

Whether an anemia is due to a chronic blood loss or to a toxic influence the history and special examinations will best differentiate A careful study of the morphology of the blood will serve to detect a co existing blood disease such as leukemia

Chemical examination of the blood for sugar is indicated in diabetes in oliguria the non protein blood nitrogen should be determined if uremia is suspected Attending the copious vomiting of high intestinal obstruction, dechlorination and dehydration with elevation of the non protein blood nitrogen decrease of the plasma chlorides and alkalosis occur (increased combining power of the blood for carbon dioxide) These alterations do not occur in the presence of adequate fluid administration which insures the satisfactory output of urine and corrects the above findings if they exist These findings occur rarely in low obstructions The determination of these values in the blood is not essential for the recognition of bowel obstruction In atypical cases however valuable information may be gained from them If there be any question concerning the state of hydration of the patient determination of the values for the non protein blood nitrogen the plasma chlorides and carbon dioxide combining power of the blood will help to decide the issue

Roentgenography

The employment of the x ray supplies evidence on two important considerations In no other manner is reliable information to be obtained

of an enema The duodenal tube has superseded the enema in the relief of intestinal distension

E LABORATORY PROCEDURES

The Urine

A urine examination is to be made a matter of routine in every patient with an acute abdominal disorder Its greatest worth resides in its value is a safe guard in detecting lesions of the urinary tract and particularly of the kidney which might in atypical instances be mistaken for appendicitis, salpingitis of the Fallopian tube, or other intraperitoneal disorder Microscopic examination of the sediment of a centrifuged specimen will serve to identify instances of pyuria or hematuria occasioned by urinary infection or stone In the febrile state of peritonitis, occasional white and red blood cells are observed commonly in the urinary sediment Chemical examination of the urine for albumin and sugar will serve to recognize systemic diseases which may be present concomitantly as nephritis or diabetes A faint cloud of albumin is present not uncommonly in febrile conditions The finding of urinary sugar should suggest the necessity of ascertaining definitely whether the patient may have diabetes—a very important consideration in the administration of fluid as well as in the ultimate prognosis In this connection it may well be recounted also that the acidosis of diabetes per se may simulate almost any acute abdominal disorder An antecedent story of nausea, vomiting, and abdominal pain is elicited frequently and, on physical examination, the abdomen may be found rigid The flushed cheeks, the acetone on the breath and the acetone bodies in the urine will identify readily the true state of affairs In such cases a blood sugar determination should be made and the degree of acidosis ascertained by an assay of the combining power of the blood plasma for carbon dioxide

In urinary tract disorders, more elaborate clinical chemical, and bacteriological tests are frequently necessary which lie outside the province of a chapter on general diagnosis of acute abdominal lesions The writer has had no experience in evaluating the significance of indicanuria in bowel obstruction It need not be looked upon as a diagnostic sign of any great value The importance of determining the daily urine output in patients with acute lesions whether treated conservatively or by operation, can not be over emphasized A satisfactory twenty four hour urinary excretion (700 to 1000 cubic centimeters) in which the presence of sodium chloride can be demonstrated is a good and practical test of an adequate fluid balance, and affords the best guide in the determination of how liberally para oral fluids should be administered It is a good plan to have the nurses record the specific gravity of each voided specimen of urine When the specific gravity exceeds 1 024 the administration of larger quantities of para oral fluids is indicated It is to be remembered, however, that excretion of sodium chloride and glucose in the urine tend to keep the specific gravity of the urine high

appearance of the film If the distension be limited to the colon, he is likely to affirm the presence of mechanical obstruction of the colon, if the small intestine alone is distended and no evidence of separation of intestinal coils by fluid is suggested he is likely to diagnose mechanical obstruction of the small intestine, and if distension concerns both the large and small bowel and particularly if fluid separates intestinal coils he will probably make a diagnosis of ileus due to peritonitis (Fig 18) Now, to be sure, these are the typical roentgen findings of each of these afflictions It is, however, decidedly unsafe to express an opinion from the roentgen evidence alone and this practice of roentgenologists should be discouraged The appearance of thickening of the bowel wall on the x ray film owing to the transudation of fluid into the peritoneal cavity, may occur in simple but more often in strangulating obstructions, as well as in peritonitis The auscultatory phenomena elicited when correlated with the roentgen findings relating to intestinal distension afford a much more worthwhile opinion And when the events of the history and the physical examination and the findings on gastric intubation are integrated into this judgment a trustworthy decision will in all likelihood be made



Fig 19—X ray film taken in the erect posture to demonstrate the presence of pneumoperitoneum This finding indicates escape of gas from the gastro-intestinal tract

When gas is observed in the free peritoneal cavity of the patient with an acute abdominal lesion the roentgenologist is almost invariably correct when he states that a leak has occurred in the gastro intestinal canal (Fig 19) Apart from the occasional finding of a pneumoperitoneum of unexplained origin without symptoms the only condition which may give rise to confusion would be the production of gas in an intraperitoneal abscess by the activity of bacteria—a very rare occurrence in the experience of the writer If the patient has a very rigid abdomen and suffered immediate and great disability from the onset and a film properly made fails to show gas below the diaphragm the clinician should not be deterred from making a diagnosis of perforated ulcer In such an instance the site of perforation was probably quickly sealed off with a wisp of fat from the gastrocolic or gastrohepatic omentum Instances of this nature have come to the writer s attention where the examiner guided by the clinical findings believed that perforation had actually occurred urged the roentgenologist to give the patient a few swallows of barium when no gas could be demonstrated beneath the diaphragm Observing that the barium remained within the confines of the stomach and duodenum the examiner concluded that the ulcer was perforating in type only later to find that gas had now become visible beneath the diaphragm When gas cannot be demonstrated beneath the diaphragm, in the type of case just

concerning these two particulars, viz (1) the grade of intestinal distension and the location of the distended coils and (2) whether free gas is present in the peritoneal cavity To be certain, it is not necessary in every acute abdominal condition to secure exact information on these points It is when bowel obstruction is suspected that enlightenment is especially sought concerning the state of intestinal distension, in the distension accompanying paresis of the bowel attending many acute abdominal dis-

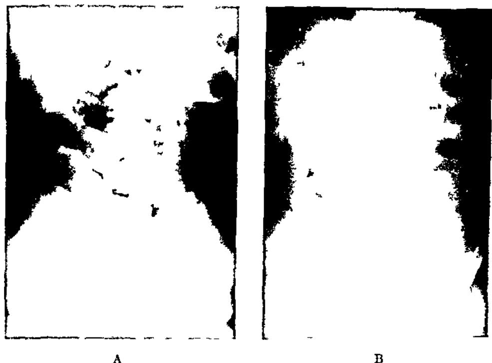


Fig 18—X ray films of the abdomen in peritonitis It is apparent that more information is obtained from the film made in the supine position (a) than from that taken with the patient erect (b) In the latter gas is mirrored over fluid in (a) the grade of intestinal distension can be made out and the apparent thickening of the wall of a dilated bowel suggests that fluid is present between the coils On auscultation the abdomen was silent In all borderline conditions in which the possibility of perforation suggests itself the erect film should always be made

orders as well as after abdominal operation, only a roentgen film can give dependable information concerning the degree and character of the distension Aside from the instances in which perforation of the gastrointestinal canal is inferred from the history and the physical examination, the search for free gas in the peritoneal cavity is indicated in every borderline condition in which evidence suggests the presence of peritonitis, but an exact or satisfactory diagnosis can not be made

It is to be emphasized concerning the interpretation of films, as it relates to the state of intestinal distension, that this information must be integrated into the clinical picture Too often, a roentgenologist unfamiliar with the details of the history or physical examination essays to determine whether mechanical or inhibitive (paralytic) ileus is present on the sole

appearance of the film If the distension be limited to the colon, he is likely to affirm the presence of mechanical obstruction of the colon, if the small intestine alone is distended and no evidence of separation of intestinal coils by *fluid is suggested, he is likely to diagnose mechanical obstruction* of the small intestine, and if distension concerns both the large and small bowel and particularly if fluid separates intestinal coils, he will probably make a diagnosis of ileus due to peritonitis (Fig 18) Now, to be sure, these are the typical roentgen findings of each of these afflictions It is however, decidedly unsafe to express an opinion from the roentgen evidence alone, and this practice of roentgenologists should be discouraged The appearance of thickening of the bowel wall on the x ray film owing to the transudation of fluid into the peritoneal cavity, may occur in simple but more often in strangulating obstructions as well as in peritonitis The auscultatory phenomena elicited when correlated with the roentgen findings relating to intestinal distension afford a much more worthwhile opinion And when the events of the history and the physical examination and the findings on gastric intubation are integrated into this judgment, a trustworthy decision will in all likelihood be made



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referred to, the examiner must not discard and abandon the clinical evidence *in favor of the negative roentgen findings* When the clinical evidence points to ulcer perforation, but air can not be demonstrated below the diaphragm, Beck injects air into the stomach through a duodenal tube and places the patient in the left lateral decubitus Beck finds that, not uncommonly, air can now be demonstrated below the diaphragm on a roentgen film when the patient is returned to the erect position

Unfortunately, in perforations of the bowel, gas can not be demonstrated so readily beneath the diaphragm as in ulcer perforation Whereas 5 cubic centimeters of gas may be visualized not uncommonly (Paine and Rigler), *it takes often as much as 20 cubic* centimeters to separate liver and diaphragm The stomach bubble on the left may give rise to confusion and should be removed by aspiration with a tube, in case of doubt In the *experience of this clinic, perforation of the appendix* gives rise to a visible pneumoperitoneum, only very rarely

He who has oriented himself concerning the value of the x rays with *reference to the particulars described above finds it an indispensable aid* He must, of course, also be familiar with its shortcomings and limitations

Now and then, one hears a voice *raised to protest that only the old* tried methods of the history and physical examination are of any *value in the recognition of acute* abdominal afflictions He, who essays to express such judgments, *without access to the x rays* in the elucidation of the two issues related above does not appreciate adequately what help he is denying himself



Fig 20—Rupture of the retroperitoneal duodenum Gas is shown around the right kidney and colon

Method of Taking the Film—To ascertain the degree of intestinal distension and the location of the distended coils, the film is best made with the patient lying supine, as will be described further in the next chapter Determination of whether free gas is present in the peritoneal cavity is to be made preferably with the patient standing or sitting upright If he is too ill to assume these postures the film should be made in the left lateral decubitus with the presence of gas sought for on the film between the right border of the liver shadow and the abdominal wall Rupture of the retro-peritoneal duodenum or colon may be recognized on the film taken with the patient lying supine and is disclosed by the appearance of gas external to the colon surrounding the kidney (Fig 20) *The oral* administration of barium to patients with acute intestinal obstruction is to be discouraged Better evidence can be obtained sooner by careful examination of the scout film *of the abdomen Occasionally, it becomes*

necessary to give a thin barium mixture by rectum to decide whether a distended intestinal coil concerns the large or small intestine In acute great distensions of the colon suspected of being mechanical in origin, the writer has not found the barium enema as reliable, even in expert hands, in deciding whether a mechanical or functional obstruction is present, as is this same agent in the detection of a localized lesion of the colon, when distension is absent If the distension of the colon is great and intestinal colic is present, even though the roentgenologist fails to disclose the presence of a lesion in the colon with a barium enema, decompressing the bowel by colostomy must be considered strongly Two instances have come to the writer's attention in which so much reliance was felt in the roentgenologist's findings and opinion that the distension was ignored perforation of the cecum occurred and at necropsy a small but definite obstructing lesion was found in the pelvic colon Viewing of the patient in the lateral positions beneath the fluoroscope and the taking of films in many positions serve to increase the likelihood of an obstructive lesion being visualized

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obstruction is to decide whether *intestinal colic* is present Intestinal obstruction of mechanical origin without *intestinal colic* does not exist Having decided the presence of *intestinal colic*, it remains to be determined whether it be due to an actual block in the bowel to enterocolitis, food allergy or indiscretion On the basis of such general symptoms as vomiting distension, fever, and diarrhea this differential is made easily, usually

Singularly enough obstructions at the pylorus which are observed clinically do not appear to give rise to a colicky type of distress nor do obstructions of the efferent loop at a gastrojejunal stoma In other instances of mechanical intestinal obstruction observed by the writer whether the occlusion was found a few inches beyond the duodenojejunal angle or in the rectum intermittent colic or gas pains' were present, their origin in hyperactive intestinal contractions could be established definitely by the recurrent concurrence of audible borborygmi and colic

The Vomiting of Bowel Obstruction

One of the characteristics of the vomiting of obstruction, as distinguished from other acute abdominal lesions is that it tends to be more frequent and abundant The rationale of this occurrence is readily apparent in the existence of a mechanical block in the bowel, which brings about a regurgitation of the stagnant intestinal content into the higher reaches of the alimentary canal When accumulation occurs in the stomach vomiting is copious usually

There are observed clinically, not infrequently instances of mechanical obstruction in which the distension may be enormous and yet no vomiting occur These are invariably found to be instances of obstruction of the colon The explanation is more readily apparent in the character of the distension under which caption this feature will be discussed in some detail Observation of clinical cases of obstruction has brought the conclusion upon the writer that feculent vomiting is uniformly an accompaniment of obstruction of the small intestine that *intestinal colic* attended by considerable distension without vomiting is usually due to obstruction of the colon When a duodenal tube is passed into the stomach, in instances of obstruction of the colon no retention is found usually, and when fluid is recovered it exhibits the features of gastric or biliary content Invariably however in obstruction of the small intestine of moderate grade unless vomiting has just occurred gastric retention is found to be present The fluid recovered is frequently yellowish brown with the stercoraceous odor peculiar to the lower reaches of the small intestine

It is apparent from what has been said previously concerning the ileocecal sphincter that it is responsible for these differences between obstructions of the small and large intestine Under the caption of roentgen observations, this point will be elaborated further The physical findings of obstruction will be described under the heading of How is the bowel obstructed?

General Physical Findings

On the whole very little help is afforded by the general condition of the patient in the recognition of bowel obstruction His appearance usually

Chapter III

THE RECOGNITION OF OBSTRUCTION

The significance of early diagnosis is attested in every reported series of obstruction where reference is made to mortality. It is stated frequently that, instances of bowel obstruction are difficult of recognition, especially because the physical findings are meager. It is the purpose of this discussion to indicate what the criteria are upon which a timely diagnosis may be made with some assurance. In particular, evidence will be presented upon which one may decide (1) whether obstruction is present, (2) what the location of the obstruction is, (3) whether the obstruction is complete or incomplete, and (4) the manner in which the bowel is obstructed.

A IS THE BOWEL OBSTRUCTED?

The common complaints of patients with bowel obstruction are three (1) pain, (2) vomiting, and (3) distension. These complaints, it is true, are so much a part of all acute abdominal lesions that their occurrence affords no satisfactory distinguishing characters. The pain like that of other abdominal colics is crampy and intermittent, the vomiting is often frequent and copious and when the patient presents himself for examination, distension is present almost invariably.

Pain

The enhanced contractile activity of the gut in consequence of the presence of the intestinal block gives rise to intermittent crampy pain. The distress comes on suddenly, increases in crescendo fashion quickly reaching its maximum grade of severity which intensity is maintained usually for one to three minutes then the pain decreases and ceases as abruptly as it began. After free intervals of varying length the pain recurs again and again. Transudation of blood and fluid into the peritoneal cavity as occurs in strangulating obstructions, gives rise to a more continuous type of pain and gives rise to tenderness also.

The Significance of Intestinal Colic

Concomitant with these recurrent pains noises varying in quality with the character of the distension may be heard over the abdomen with a stethoscope at the acme of the pain. If the bowel is considerably distended by gas these sounds have a metallic character free admixture of gas and fluid in the distension is indicated by bubbling gurgling noises.

The synchronous concurrence of pain and noise (borborygmus) establishes the painful contraction as *intestinal colic*. Whereas *borborygmi* may be detected over the abdomen in other acute abdominal disorders there is no intimate time relationship as occurs when the cramp is of intestinal origin.

The first step therefore in determining the absence or presence of bowel

belies the presence of a potentially serious ailment The respiration an blood pressure are normal usually The pulse and temperature may l elevated slightly above the normal values Apart from the pain of whic the patient with obstruction complains, and the vomiting and the disten sion, he may not appear particularly ill Late in obstruction, owing t dehydration and other changes in bodily economy not wholly understoo an anxious expression with sunken features, a feeble pulse, and cold an livid extremities may be observed

In strangulating obstructions, especially if the segment be long whos blood supply is compromised, the pulse may be hurried, if the blood los is great, the symptoms of shock are present usually Owing to the irrita tion of the parietal peritoneum by the sanguineous fluid escaping into th peritoneal cavity, such a patient suffers more distress than the patien with simple obstruction

Laboratory Aids

Similarly little specific help in the diagnosis of obstruction is obtaine in general laboratory procedures When vomiting has been a prominen feature, hemoconcentration occurs and increased values for hemoglobin red cells, and leucocytes may be found Demidova has observed concen tration of all the elements of the blood in high intestinal obstructions an describes red cell counts of 6,000,000, hemoglobin values of 120 per cent and leucocyte counts as high as 30,000, with a tendency to appearance o immature forms In low obstructions Demidova found changes from th normal less frequently McKittrick and Sarris (1940) stress rightfully the importance of a rising leucocyte count as an indication of a strangu lating obstruction Yet, in their cases, the highest leukocyte count (38,000) was observed in a patient with simple obstruction In this connection, it should be mentioned that Hill and Stoner (1941) observed leucopenia in dogs when intravenous injections were made from fluid recovered from the peritoneal cavities of other dogs with strangulated intestinal loops When the fluid injected intravenously represented a transudate from obstructed loops (not strangulated), leucopenia was observed less frequently The urine is usually scant and albumin or casts may be present The kidney function is not impaired, for the liberal administration of saline solution corrects the oliguria and the abnormal urinary findings disappear

Elevations in the non protein nitrogen of the blood decrease in the blood chlorides and an increase in the combining power of the blood for carbon dioxide occur only with regularity in clinical obstructions at the outlet of the stomach and the upper jejunum and then usually only after considerable fluid has been lost over a 48 hour interval These changes are not observed in low obstructions, indicating that enough fluid must be absorbed from the gut to preclude serious loss of electrolytes In conse quence, these chemical alterations which may attend obstruction are not to be relied upon for diagnosis In atypical instances they may be of some value

X ray Observations—*It is immediately* apparent that the abdomen or the lungs for that matter, would be as dull on percussion as the liver

were it not for the presence of gas within these viscera. The distension of obstruction exhibits rarely any distinctive characters of which one can be certain clinically. With the aid of the radiographic film, however, one can procure reliable information as to the degree, extent, and location of distended segments of bowel.

Gas is normally present throughout the alimentary canal. Under normal conditions it is visualized on the roentgen film of the adult's abdomen only in the stomach and colon, the sites where food and intestinal content remain for some time. Whereas gas is present throughout the small intestine, the admixture between fluid and gas is so intimate because of the rapid rate of transit through the small bowel that gas is not visualized on the roentgen film. Under conditions of stasis in the small intestine, however, be the cause inhibitive (paralytic) or mechanical, gas and fluid separate out and gas is visualized. In the normal infant and child, however, gas apparently is visualized ordinarily in the small intestine until about three years of age. Following the establishment of experimental obstruction of the small intestine of the dog, it has been found that gaseous distension may be observed regularly on the roentgen film after four to five hours. Visible gas in distended loops of small intestine in the adult is, perforce, synonymous with intestinal stasis. The stethoscope serves to distinguish whether the stasis is of mechanical or inhibitive (paralytic) origin.

B. WHERE IS THE OBSTRUCTION?

The roentgen film of the abdomen, interpreted in the light of the clinical findings, gives reliable information concerning the location of the obstruc-

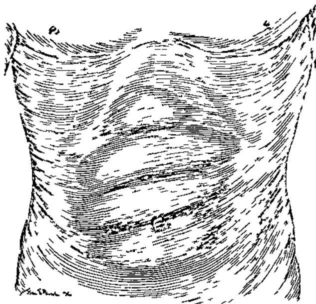


FIG. 21.—Visible and palpable coils of bowel in stricture of the small intestine.

belies the presence of a potentially serious ailment The respiration and blood pressure are normal usually The pulse and temperature may be elevated slightly above the normal values Apart from the pain of which the patient with obstruction complains, and the vomiting and the distension, he may not appear particularly ill Late in obstruction, owing to dehydration and other changes in bodily economy not wholly understood, an anxious expression with sunken features, a feeble pulse, and cold and livid extremities may be observed

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X ray Observations—It is immediately apparent that the abdomen, or the lungs for that matter, would be as dull on percussion as the liver,

shadows in the obstructed small intestine may be described as a step-ladder arrangement of the coils, the mucosal folds of Kerkring within the bowel lend a feathery appearance Acute angulations are described aptly as 'hair pin turns" In the ileum, the valvulae conniventes are less prevalent than in the jejunum, in consequence, distended coils of ileum are more blank and somewhat characterless as contrasted with the feathery appearance of distended jejunal coils and the haustral markings of the distended colon

Ordinarily, no difficulty exists in telling whether a given gaseous segment of distension concerns the small or large intestine In atypical instances, however, it may be very difficult In the main, the greatest difficulty lies in differentiating, with accuracy in borderline cases whether the distension concerns the jejunum or the colon Often, in such instances, the clinical signs fail to give a clear lead also The feathery appearance of the distended jejunum may in certain cases, be imitated so closely by a distended colon, as to preclude absolute differentiation Because of its somewhat characterless appearance, distended ileum can be distinguished from the upper jejunum as well as a distended colon quite readily If the choice of therapy is influenced by whether the distension concerns the jejunum or the colon, a barium enema should be given for purposes of ascertaining which viscus the areas of distension concern When doubt remains and the situation demands detection of where the distension is the administration of a thin mixture of barium as an enema will differentiate

Almost as important as *intestinal colic* is in confirming the presence of bowel obstruction, is a proper appraisal of the distinguishing features between large and small bowel obstruction in determining which variety is present This difference in behavior is predicated on the action of the ileocecal valve and sphincter as a check valve precluding regurgitation from the distended colon into the terminal ileum in obstruction of the colon yet permitting the fluid excreted into the upper reaches of the intestinal canal and swallowed air to make their way, unimpeded apparently into the colon In con quence there is frequently no gastric retention in obstruction of the colon and feculent vomiting is *always* absent and vomiting is frequently entirely absent Now and then, reflex vomiting may be present initially When the duodenal tube is passed and suction applied, only gas is re aspirated usually and occasionally small amounts of fluid which can be identified as having its origin in the stomach or upper small intestine Several instances of perforation of the cecum unassociated with vomiting occasioned by such rises of intra luminal pressure in colon obstructions as to cause necrosis of the bowel wall have come to the writer s attention In one of these the occlusion was a small annular carcinoma at the beginning of the ascending colon not more than four centimeters above the point of entrance of the ileum into the colon This is probably the only type of bowel obstruction which may not be accompanied by early distension (Fig 22) The more usual location of the obstruction which gives rise to perforation of the cecum is in the more distal reaches of the colon and particularly the pelvic colon

tion In the writer's experience, the distension of acute obstruction of the large bowel is limited usually to the colon Even at operation the terminal ileum is found not distended, as a rule It is not to be denied that occasionally the small intestine may participate in the distention of an obstructed colon—the reason being that one of the lips of the ileocecal valve is deficient

The ileocecal sphincter and valve operate in the manner of a check-valve, permitting gas and fluid from the small intestine to be swept into

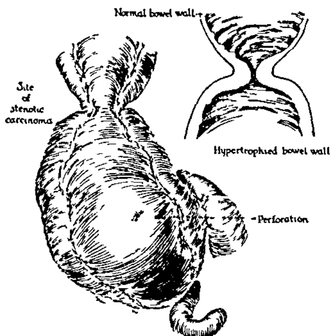


FIG 22—Tension perforation of cecum due to carcinomatous stricture of ascending colon The patient a physician had intermittent gas pains for six months There was no vomiting or distention prior to perforation

the colon, but having once entered, their re entry or regurgitation into the small intestine is prevented by the sphincteric mechanism The failure of the small intestine to participate in the distension accounts for the frequent absence of any vomiting in colonic obstructions

Determination of whether the distension observed on the film concerns the small bowel or colon is made readily usually Gas in the small intestine is characterized by its central location the long axis of the shadow is usually transverse and, when the loops are considerably dilated the two intestinal walls separating adjacent loops are seen as a very thin and narrow wall The occurrence of a fairly thick wall separating greatly distended loops suggests the presence of fluid or exudate between them Gas at the lateral borders of the abdomen is ordinarily in the colon the long axis is usually vertical and the intestinal walls are thicker and haustral markings are frequently in evidence The typical appearance of gaseous

Intestinal colic with distension limited to the colon indicates that the site of the obstruction is in the colon (Figures 12 and 23) The exact location of the obstruction in the small intestine cannot be determined with the same accuracy as in the colon On the whole however, from the pattern of arrangement of intestinal coils described by Mall, one can readily tell whether the obstruction is in the upper, middle, or lower thirds of the small bowel

How Should the Film Be Taken?

The film made with the patient lying supine gives the best information as to the pattern of arrangement of the distended intestinal coil Even



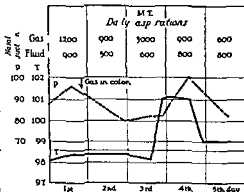


FIG 24—Roentgenogram in acute obstruction due to carcinoma of the ileocecal valve and sphincter Obstruction at the ileocecal valve occludes the small intestine Mr M T aged 64 was admitted to hospital with a story of recurrent attacks of crampy abdominal pain and vomiting extending back over several months The present attack began about four days previously (a) The roentgenogram indicates the distension This film was taken in the usual manner with the patient lying supine (b) This radiograph was made with patient lying upon his abdomen The distended coils being nearer the plate the diameter here shown approaches more accurately the true distension It is apparent however that the continuity of the distended coils can not be determined as in A Following decompression accomplished by an indwelling duodenal tube the administration of a barium enema revealed a filling defect in the cecum A carcinoma was excised successfully (c) The reaction attending decompression and the quantity of fluid and gas aspirated are shown in the graph

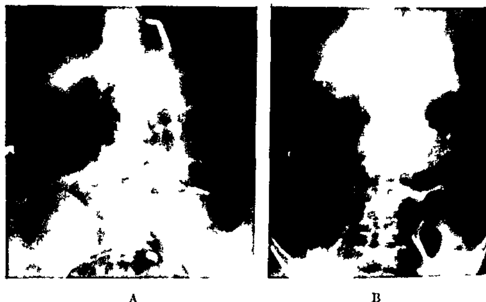


Fig 23—Obstruction of the colon (a) Film taken with patient lying supine The opaque circular object is a five cent piece taped over the umbilicus It lies on the anterior abdominal wall and is nearest the film and in consequence is enlarged considerably its diameter on the original film was one-third greater than actual size The bowel lying within the peritoneal cavity is further from the film and its diameter is magnified correspondingly less (usually about 25 per cent) (b) Film taken with the patient lying prone The five cent piece and its shadow on the original diagram had identical diameters The diameter of the distended colon shown here is more like that observed at operation Lying on the abdomen has forced gas into the small intestine The smooth outline of the mid-sectional group of coils definitely stamps them as being ileum (See also Fig 12)

These occurrences attest well the usual competency of the ileocecal valve and sphincter in preventing retrograde flow into the small intestine Yet, if the lower lip of the ileocecal valve should be deficient, the orifice would be patulous and regurgitation into the ileum could occur

Distension is common to all varieties of bowel obstruction In the more chronic types of occlusion, the fluid content of the obstructed bowel at operation is found to be considerably greater in amount usually than in the acute obstructions in which gaseous distension is ordinarily prominent In the dog, accumulation of gas in a segment of gut just proximal to an artificially established obstruction in the small intestine may be detected on an x ray film after four to six hours Usually, when patients come under observation, for obstruction, distension recognizable clinically is present

Distension, nausea, and vomiting with feculent regurgitation accompanied by *intestinal colic* indicate the presence of obstruction of the small intestine Distension, frequently of high grade, unattended by nausea or vomiting, with no return of colored intestinal fluid on gastric aspiration, but accompanied by *intestinal colic,* is synonymous with obstruction of the colon The value of the roentgen examination lies in affirming these impressions and revealing the exact location of the distended segments of bowel

measurement of the diameter of the distended intestinal coils gives information of real value With employment of conservative means of decompression, it is particularly desirable to ascertain by measurement, whether the calibre of the distended intestine is being reduced by the exertion of suction

A large film is placed beneath the patient, with the cone of the x ray tube 30 inches from the plate Almost invariably, the x ray technician, unless instructed, will take the film too low—so low, that a good portion of the femur shows on the x ray film In most intestinal obstructions, that portion of the abdominal cavity, shown on the film below the great trochanter of the femur, exhibits rarely any useful information to aid in making the diagnosis of obstruction The writer has made it a rule, therefore in the taking of scout films to determine the presence of distension, in suspected bowel obstruction that, the lower margin of the film come not lower than one centimeter below the anterior superior spine of the ilium A film taken in this manner shows the diaphragms, the stomach, and the location of the indwelling duodenal tube, as well as the large area of the greater portion of the abdomen

C IS THE OBSTRUCTION COMPLETE OR INCOMPLETE?

The grade of distension of the distended coils is a fair but not an absolute measure of whether the obstruction is complete Inasmuch as the ileocecal sphincter and valve make of the colon a closed loop, complete obstruction of the large bowel is soon attended by alarming distension of the colon and particularly of the cecum, for it is the most distensible Incomplete obstructions of the colon are attended by lesser grades of distension and gas is evacuated by rectum usually

Whether obstruction is complete or not in the small intestine is to be determined by whether gas is observed to persist in the colon or on the roentgen film after a preliminary evacuant enema has been administered This thesis is predicated on two facts (1) The chief source of gas in the intestine is swallowed air (2) The bowel distal to the obstruction is functionally as well as anatomically normal and its content may be removed with enemas Considerable distension of the small intestine, without the presence of visible gas in the colon after preliminary evacuant enemas indicates that the obstruction is complete (Fig 26), distension of the small intestine accompanied by persistence of gas in the colon identifies an incomplete bowel obstruction, when distension of the small intestine is accompanied by persistence of gas in the colon, an incomplete obstruction is suggested by these findings (Fig 27)

D HOW IS THE GUT OBSTRUCTED?

The gut may become obstructed in a number of diverse manners From the anatomic standpoint, however, there are but two types of obstruction with variants in degree viz (1) simple obstruction presenting interference to the continuity of the bowel alone (2) strangulating obstruction which exhibits in addition to a block in the bowel, compromise of the blood supply

The abdominal physical findings of these two anatomic varieties of ob

though the distended loops appear somewhat larger than they really are, it is the only exposure in which the distended coils can be traced through in continuity When the film is made with the patient lying prone, a truer diameter of the intestinal coils is obtained, the bowel being near the plate Owing to the pressure upon the intestine with the patient lying on the abdomen however, the continuity of distension cannot be followed through It is also apparent that enough gas must be present in the dis tended bowel to afford adequate contrast, if the distension were wholly or largely fluid (a rare occurrence), the actual degree of intestinal disten sion may not be apparent in many coils

A film made in the erect or lateral posture permits of visualizing "gas eous mirrors over fluid levels in the bowel No reliable information can be obtained from such a film as to the exact location or the actual degree of intestinal distension present Under ordinary circumstances, therefore, a single large film of the abdomen (scout), taken with the patient lying supine is the most valuable in that it gives the most desired information In chronic obstructions in the presence of considerable fluid in the bowel, an erect film is more likely to detect the presence of gas, mirrored over the fluid, than is the film taken with the patient supine

A number of measurements made of distended intestinal coils at opera tion and compared with the diameter of the distended coils on the x ray film suggests that the antero posterior film, made with the patient lying supine, occasions an enlargement of the true intestinal diameter of about 25 per cent A five cent piece fastened over the umbilicus with adhesive tape lies nearer the source of the x rays, and owing to the greater diffrac- tion of the rays, exhibits an enlargement of 33 per cent, in the patient with an abdominal wall of ordinary thickness (See Fig 23) With these factors in mind the clinician may obtain reasonably accurate information from the x ray film, concerning the true diameter of the distended intestinal coils It is obvious that in the case with simple obstruction, at least, the



FIG 25—On first glance this film would suggest a mechanical obstruction of the small intestine The outer wall of jejunal coils however can be seen—a finding which indicates that air must be present in the peritoneal cavity An erect film verified this suspicion The initial story had been one of intestinal colic without vomiting On the basis of the history and this roentgen film a diagnosis was made of carcinoma of the colon with perforation of the cecum (permitting de compression of the di tended colon into the peritoneal cavity) At operation an annular carcinoma was found at the hepatic flexure and the perforation in the cecum was closed From the history one would infer that the perforation had been present about 5 hours The patient of course did not survive peritoneal soil ing in the presence of obstruction is al most invariably fatal

struction are sufficiently distinctive usually to permit of differentiation The patient with a simple block in the bowel exhibits no tenderness or rigidity of the abdominal wall unless the gut is so distended that its wall weeps If, however, the return flow of blood through the mesenteric veins is interfered with the gut becomes infarcted and a sero sanguineous fluid escapes into the peritoneum causing the latter to become sensitive If a considerable segment of bowel becomes infarcted, a tender mass may be made out over the abdomen or by digital examination of the rectum or vagina Intussusception is the single variety of strangulating obstruction in which the abdominal wall may be found to be relaxed and not tender The explanation is quickly apparent in that the infarcted intussusceptum is within the normal ensheathing layer When bloody fluid escapes into the peritoneal cavity as happens occasionally tenderness is present The other findings such as mass and evacuation of blood and mucus by stool are sufficiently distinctive to serve to identify its presence During the colic the abdominal wall may stiffen and relax in the free interval Similarly, in simple obstruction a tightening of the abdominal wall may be made out when the patient is suffering pain The same effect may be observed with an inflated balloon or upon faradic stimulation with an electrode within the gut



Fig 28—The x-ray in chronic obstruction of the small intestine Films made two hours after the oral administration of barium in a patient with chronic intestinal obstruction Ten years previously this patient had suffered with tuberculous peritonitis Barium is not to be given in acute obstructions

Intestinal colic without tenderness of the abdomen signifies the presence of a simple obstruction *Intestinal colic* accompanied by abdominal tenderness suggests that a strangulating obstruction is present The grade of rigidity of the abdominal muscles is usually not great for blood is not as severe an irritant of the parietal peritoneum as is hydrochloric acid (0 5 per cent) which, when pilled into the abdomen following spontaneous perforation of an ulcer, gives rise to a board like abdomen Purulent affections of the peritoneum also give rise to a greater grade of rigidity than that attending the escape of blood into the peritoneal cavity Occasionally, in simple obstruction because of increased intraluminal tension, the gut may weep and fluid will be transuded into the peritoneal cavity, giving rise to tenderness suggesting necessity for operative intervention

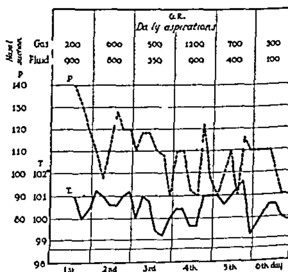
McKittrick and Sarris (1940) are not willing to allow that abdominal



FIG 26—Complete obstruction of the small intestine Mrs F H aged 29 (Table 16 p 138 Case I) Radiograph of abdomen on entry to hospital after 96 hours of abdominal pain and vomiting Intestinal noises with a metallic character were heard with the stethoscope at the height of the recurrent pains establishing the presence of intestinal colic Numerous enemas had been administered prior to admission and no gas was visualized in the colon indicating that the obstruction was complete There were no signs of peritoneal irritation The patient convalesced satisfactorily after enterostomy The fluid drainage is indicated in Table 13 The relatively small escape indicates that the continuity of the bowel was restored quickly



A



B

FIG 27—Incomplete obstruction of the small intestine (a) *Radiograph of abdomen* of Miss G R aged 20 Crampy abdominal pain and profuse vomiting of 24 hours duration There was no abdominal tenderness Appendectomy was done for suppurative *appendicitis three months previously There is moderate* distention of several coils of small intestine gas is also present in the colon after evacuant enemas have been given indicating that the obstruction is incomplete (b) The patient was satisfactorily decompressed by suction applied to an inlying duodenal tube The quantities of fluid and gas aspirated and the length of time over which suction was exerted are indicated in the accompanying graph as are also the pulse and temperature reactions attending the employment of suction There has been no recurrence of symptoms of bowel obstruction in the intervening seven years

delay in transit of barium through the small intestine as determined by the 'stasis ray' The patient may take a full diet containing a good deal of cellulose, which ordinarily leaves considerable residue, without ill effect Suddenly acute obstruction supervenes with pain and vomiting and the 'washboard' abdomen with elevations and depressions occasioned by the hypertrophied gut is readily made out Such an attack may then subside to be followed by comparatively long intervals without symptoms (See p 82)

F IDENTIFICATION OF THE TYPE OF OBSTRUCTION

The exact nature of the obstructing agent and the precise manner in which it obstructs the gut are items upon which information at best is inferential and not absolute External hernias, the congenital obstructions such as intestinal atresia and imperforation of the rectum and anal canal, intussusceptions of infancy, and mechanical obstructions of the left colon may be identified with accuracy usually by the rather obvious findings or characteristic train of symptoms present Occasionally, functional spastic obstructions with considerable distension of the colon may be confused with obstruction of the pelvic colon due to carcinoma or diverticulitis, but the aid of the barium enema serves to differentiate usually The greatest difficulty is in accurate recognition of the exact nature of an obstruction in the small intestine When strangulated external hernia and invagination of the bowel which are statistically rather common varieties of obstruction are excluded adhesive obstruction is by all odds the most likely It is probably the most frequently observed of all varieties of obstruction and concerns almost invariably the small intestine alone Yet, obstruction of the small bowel by a gallstone carcinoma of the small intestine or an enteric intussusception though uncommon occur sufficiently frequently to demand attention in the consideration of the probable nature of a small bowel obstruction and even obstruction of the intestine by a band may be difficult to identify without operation

In the experience of the writer one of the most difficult differential diagnoses is to distinguish between a strangulating type of obstruction presenting *intestinal colic* and rebound tenderness and atypical acute inflammatory lesions which in turn may be complicated by simple obstruction The history, the degree of tenderness present, and the distribution of gas in the gut aid materially often in differentiating In those inflammatory lesions however in which the obstructing element is such that a fairly complete obstruction exists, it may be impossible to differentiate

G ESTABLISHING THE DIAGNOSIS

There usually is no difficulty in ascertaining that the gut is obstructed In any acute abdominal disorder presence or absence of obstruction is determined readily usually by the presence or absence of *intestinal colic* At the same time, one can with the aid of a radiographic film as has been indicated determine whether the obstruction concerns the colon or the small intestine The absence or presence of vomiting as well as the occurrence and grade of gastric retention as determined by aspiration afford a valuable clue The grade of intestinal distension and whether the obstruction is

tenderness will serve to distinguish simple and strangulating obstructions. Yet, of all the differential characters, it is unquestionably the most reliable. At the same time, it is to be admitted freely that tenderness of the abdominal wall may be observed during the course of simple obstruction. It is wise to regard all obstructions, exhibiting definite evidences of abdominal tenderness, as instances of potential strangulation. This matter will be discussed at greater length subsequently.

Hill, O'Loughlin and Stoner (1942) have suggested recently aspiration of the peritoneal cavity with a fine needle, in suspected instances of strangulating obstruction. In dogs, they were able to recover blood from the peritoneal cavity regularly when 4 hours had elapsed after establishment of intestinal strangulation. Van Duyn (1942) believes that distension per se may cause leucopenia.

F. INTEGRATION OF THE TIME ELEMENT INTO OBSTRUCTION

The rapidity with which an obstruction develops is reflected in the clinical manifestations. On the whole, however, the element of time is not so important as the degree of completeness in determining the sequence of events. Patients presenting visible and palpable peristaltic contractions through an abdominal wall of normal thickness uniformly have an obstruction of some standing. Acute obstruction not infrequently supervenes and accentuates the symptoms. The essential difference between a bowel that has been partially obstructed for some considerable time and an acute obstruction is that in the instance of the former, the circular muscle of the bowel has had time to hypertrophy and the gut wall may be markedly thickened; in acute obstructions of high grade, the gut wall is always thin, and palpable or visible peristalsis are rarely seen.

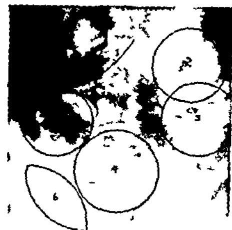


FIG. 29.—The anatomic situation of the loops of small intestine as described by Mall. The loops show up in the designated numerical sequence on roentgen study. (Morse and Naslund, *Surgery* 1: 886, 1937.)

Strictures in the bowel are the usual cause of chronic obstruction. Their most usual site is the pelvic colon, and their most usual cause is an annular carcinoma. The mild recurrent grumbling gas pains and increasing constipation, together with the contour of the palpable contractions, are tell-tale signs of its location. In the small bowel, the symptoms are dependent in large measure on the location of the stricture. A stenosis in the upper jejunum will give rise to symptoms more readily than a similar stenosis in the lower ileum, where the normal contents of the bowel are quite fluid in character. It is surprising how a high grade stenosis of the lower small intestine may be tolerated for long intervals without any demonstrable subjective or objective phenomena. There may be no detectable

Strangulating Obstructions

These are characterized by the presence of a block in the bowel with the added factor of infarction of the imprisoned segment of bowel When the interference with venous return is great, the irritation of the parietal peritoneum brought about by the escape of sanguineous fluid into the peritoneal cavity may dominate the picture in lesser grades of venous block the symptoms of peritoneal excitation may come on tardily

A large number of conditions must necessarily be thought of in the differential diagnosis of strangulating obstructions including all the abdominal colics, such as biliary and renal seizures, the inflamatory conditions such as appendicitis salpingitis and peritonitis pancreatic necrosis and diaphragmatic pleurisy purpura, hemophilia and other lesions with intestinal occlusion due to hemorrhage into the bowel wall and mesentery as well as the torsion of other organs especially ovarian cysts and the testes

Torsion of the testis concerns usually one which is imperfectly descended Absence of the testis from the scrotum, together with a tender mass in the groin or lower abdomen which may exhibit bluish discoloration serves to identify the condition Apart from the absence of *intestinal colic,* an ovarian cyst twisted on its pedicle may imitate closely the clinical features of small bowel obstruction Reflex vomiting in the beginning may be prominent later vomiting is usually absent Shoulder pain from the escape of blood into the peritoneal cavity is common Fever, leucocytosis, and a quickened pulse are frequent findings The tenderness is usually confined largely to the lower abdomen The cyst may or may not be palpated Recognition of its presence is ordinarily not difficult The stethoscope serves to differentiate the condition from a strangulating obstruction Yet fibrinous adhesions about such a strangulated cyst may give rise to concomitant simple mechanical obstruction of the bowel

The difficulty of distinguishing between a strangulating type of obstruction presenting *intestinal colic* and rebound tenderness and an inflammatory lesion which in turn may occasion some interference with the continuity of the gut was alluded to above In those inflammatory lesions in which the obstructing element is conspicuous it may be impossible to distinguish whether a strangulating obstruction alone exists or whether an inflammatory lesion complicated by a simple obstruction is present Now this differentiation is not alone a matter of academic interest moreover it is one of vital concern for the patient It has been the observation of the writer when the abdomen is opened in peritonitis where exudate is obstructing the gut that frequently the infection which the patient has been satisfactorily controlling is spread by the operative interference the barriers of resistance are broken down and the patient dies It is the writer's earnest conviction borne out by the demonstrated wisdom of conservative management in similar cases that where a strangulating obstruction can be excluded adequately a nonoperative course assumes much less risk for the patient—the distension being dealt with by suction applied to an indwelling duodenal tube

complete or incomplete can be decided by a roentgen film when preceded by the administration of an evacuant enema It may be impossible however, to distinguish clearly just the nature of the obstruction without recourse *to operation* Whether it is simple or strangulating in character may be determined with precision usually by the physical findings

II THE DIFFERENTIAL DIAGNOSIS OF OBSTRUCTION

Briefly it may be stated that cases of simple obstruction are simulated most closely by colics that are unattended by local abdominal physical findings Strangulating obstructions must be differentiated from every *colic that produces tenderness and rigidity of the abdominal wall* In both varieties the distinctive finding of *intestinal colic* serves to establish the fact that obstruction is present No other acute lesions of the abdominal viscera are attended by such a pathognomonic finding

Simple Obstruction

The number of conditions which may be confused with simple acute obstruction are not many, *for the most acute abdominal afflictions are accompanied by abdominal tenderness* The very occurrence of colicky abdominal pain without tenderness should therefore suggest the possibility of simple obstruction The lesion that early simple intestinal obstruction may be mistaken for is the simple *"belly ache"* under which category one might list food indiscretions of one sort or another intestinal allergic reactions and acute enterocolitis In these usually, diarrhea is a prominent symptom *and vomiting is missing altogether* or a minor complaint In enterocolitis, distension as visualized by roentgen examination, involves ordinarily both the large and small bowel Whereas, in mechanical obstructions whether of the *colon or small intestine, distension* is limited to the bowel concerned In obstructions of the small intestine, the colon is not distended even though in partial obstructions, gas persists in the colon after evacuant enemas have been given in acute obstructions of the colon distension of the small intestine is absent as a rule Clinical distension is slight often in early cases of obstruction The value of repeated examinations at short intervals is not to be forgotten in borderline cases



FIG 30—Roentgen films of air inflated segment of intestine A Jejunum slightly distended exhibiting mucosal folds B A jejunal segment somewhat more distended C The characterless ileum D The colon with haustral markings Distinguishing between distended loop of jejunum and colon is most troublesome source of difficulty

Strangulating Obstructions

These are characterized by the presence of a block in the bowel with the added factor of infarction of the imprisoned segment of bowel When the interference with venous return is great, the irritation of the parietal peritoneum brought about by the escape of sanguineous fluid into the peritoneal cavity may dominate the picture, in lesser grades of venous block, the symptoms of peritoneal excitation may come on tardily

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Instances of acute pancreatic necrosis are not infrequently referred to hospital under the diagnosis of bowel obstruction Here too, ascertaining whether *intestinal colic* is absent or present is exceedingly helpful Borborygmi are not uncommonly heard but *there are no associated "gas pains"* Distension of the transverse colon, together with loops of small intestine, are the usual roentgen findings An erect film helps to exclude perforation of an ulcer In contrast to appendicitis, salpingitis, and torsion of an ovarian cyst—in which conditions the findings are largely in the lower abdomen, tenderness and rigidity in pancreatic necrosis are much greater above the umbilicus than below The rigidity as differentiated from acute biliary tract disease is about equal, below both costal margins An acute lesion of the abdomen accompanied by severe pain and prostration *but without shock, not attended by intestinal colic,* and *in which the findings* are largely in the upper abdomen and about the same to the right of the midline as on the left, in which no free gas is demonstrated on an x ray film taken in the erect posture, is probably pancreatic necrosis The writer failed to recognize the true nature of this disorder in the first patient, who came under his observation, for the findings were so different from the usual textbook descriptions of the disorder Most cases of pancreatic necrosis that have been observed since, which have come to operation, have been correctly identified pre operatively by the criteria described above

Instances of perforated ulcer are to be recognized in the great rigidity of the abdominal wall and by the presence of free gas in the peritoneal cavity, observed on an x ray film made in the erect posture So called "sealed perforations may occur without free gas being visualized below the diaphragm The extreme rigidity of the abdomen and the great and immediate incapacity of the patient serve to identify the disorder

Typical instances of biliary or renal colic salpingitis, ectopic pregnancy, and appendicitis, are usually easily identified *Intestinal colic* is absent in all of them In any atypical acute abdominal affliction the two roentgen observations of the abdomen described in the previous chapter viz, the scout film and the erect plate aid materially in orienting the examiner concerning the probable pathological nature of the lesion

Distinguishing Simple and Strangulating Obstructions

The absence or presence of signs of irritability of the parietal peritoneum suffice usually to differentiate these two varieties of obstruction It is to be remembered however, that an intussusception may be unattended by rebound tenderness because the infarcted intestinal segment lies within a normal ensheathing cylinder hence, bloody fluid may not escape into the peritoneal cavity Some simple obstructions of the colon virtually become strangulating in character because of the great increase *in* intraluminal pressure, the ileocecal valve and sphincter making of the colon a closed intestinal loop In instances where the distension is great tenderness over the cecum is frequently present and portends ulceration and necrosis of the bowel wall Similarly, in an obstruction due to incarceration of a gallstone in the ileum, tenderness may come about through the agency of pressure erosion of the bowel *wall overlying the stone*

In obstruction due to the attachment of an adhesive band to the anterior abdominal wall, point tenderness at that site is usual The development and extension of abdominal tenderness in a patient whose findings were essentially those of simple obstruction constitute a warning that the features of strangulation have supervened The suggestion of a mass which may be felt through the abdominal wall or made out by rectal or vaginal examination lends strong confirmation to this suspicion These occurrences always suggest the necessity for immediate operative intervention

Employing the criteria of differentiation here described, the writer has not found himself treating a patient with strangulated bowel expectantly Yet, this accident has occurred a few times in this clinic The difficulty lies usually, in over extending the indications for conservative management of bowel obstruction It is to be remembered also that late in the course of a strangulating obstruction, the *intestinal colic* feature, so pathognomonic of obstruction may be absent altogether, owing to the inhibiting effect of increased intestinal capillary permeability upon intestinal contraction Only by sitting at the patient s bedside patiently, and auscultating over long intervals at a time, will the presence of a mechanical obstruction be detected All other evidence may point to intestinal distension, occasioned by causes other than a block to intestinal continuity The need for repeated observations and an occasional resurvey of the situation is apparent The writer, however owns to having operated with the guidance of these standards in a few instances in the fear that a strangulating obstruction was developing without actually finding it—an occurrence which, in the absence of peritoneal infection, he has had no occasion to regret The usual finding in such cases of simple obstruction has been that the bowel wept' because of the increased intraluminal pressure giving rise to exudation of clear straw colored fluid into the peritoneal cavity

STRANGULATING OBSTRUCTION WITH LITTLE OR NO EVIDENCE OF DISTENSION

Without knowledge or experience of the occurrence of a strangulating obstruction, in the absence of distension, one may be persuaded to doubt the possibility of such a happening And to be certain ordinarily the agency which brings about ensnarement of a loop of bowel or its torsion provokes a mechanical simple obstruction in the intestine immediately proximal to the strangulation In the usual strangulating obstruction therefore, there are usually two coexisting varieties of obstruction, viz , (1) strangulation of the torsioned loop and (2) simple obstruction in the intestine proximal to the site of strangulation It would seem sane to rationalize then that in order to initiate the strangulating effects of a compromised blood supply in the imprisoned loop, the strangulating mechanism should obstruct the proximal bowel In the main as has been admitted such is the usual circumstance Nevertheless as anyone who has had a wide experience with the bowel obstruction problem will bear witness occasionally a patient will present himself with a strangulating obstruction and a devitalized bowel demanding excision with little or no manifest evidence of distension There may be little or no evidence of gaseous distension on the x ray film As in most mechanical obstructions

vomiting is a predominant symptom The abdomen is usually tender and a mass can be made out occasionally

The lesson to be learned from all this is that the return of venous blood from an imprisoned loop of bowel may be impeded without the presence of a mechanical block to the continuity of the intestine This occurrence is explicable only on the basis that (1) the agency responsible for the compromise of blood flow to and from the bowel does not occlude the lumen of the bowel and (2) transport is possible through a strangulated loop of bowel, which, at operation may give every evidence of having lost its viability In mesenteric thrombosis as will be pointed out subsequently (p 453), distension and the manifest evidences of obstruction are frequently not prominent

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PART III

GENERAL THERAPEUTIC CONSIDERATIONS IN THE MANAGEMENT OF BOWEL OBSTRUCTIONS

Chapter IV

GUIDING PRINCIPLES IN THE TREATMENT OF ACUTE ABDOMINAL LESIONS

A ABDOMINAL INJURIES

World War Number II has focused attention again upon the importance of abdominal injuries In the infantry type of warfare of previous wars, the incidence of injury of the abdominal viscera as contrasted with the more frequent injuries of extremities and head was not great The mortality, however has always been very high

The abdomen is the largest cavity of the body and contains the organs dealing with alimentation and excretion, the adrenal glands which furnish the drive for our daily tasks and, in the female the genital organs These abdominal viscera may be injured in a large number of ways There are essentially two types of injury wounds sustained as the result of blunt force and penetrating wounds such as bullet and stab, or wounds made by any puncturing type of instrument The two most common consequences of abdominal injury are (1) Hemorrhage due to tears in solid viscera and (2) perforation of a hollow viscus The intestines occupy a large portion of the abdominal cavity, so it is not surprising that intestinal injuries of one sort or another represent a large percentage of injuries to the abdomen In injuries of the upper abdomen, the spleen is not infrequently injured Injury of the kidney is one of the most common sequences of blunt trauma to the abdomen Injuries of the bladder are also rather frequent About half of them are associated with fractures of the pelvis and the other half attend injuries of the lower abdominal wall The contents of the abdomen are protected in some measure by the abdominal muscles which overlay and envelop them Injuries of the abdominal viscera are obviously much more common in men than in women, due largely to occupational hazards Granted, however, the same trauma in women with lesser abdominal musculature frequently weakened by childbearing the same force will usually produce more serious damage

When violence strikes the abdomen, it is usually the viscus which is immediately beneath the site of the blow which is injured The state of digestion with reference to whether the stomach and intestine are empty or full is an important determinant in the occurrence of injury to the gastro intestinal canal A distended intestine whose wall is thin, is much more likely to be damaged than an empty contracted bowel When the bowel is fixed as at the duodeno jejunal angle and the terminal ileum, it is most susceptible of injury It is surprising how easily the gut may be

ruptured by blunt force in such areas A rather heavy woman seen in this clinic was raking her yard, stepped in a hole, lost her balance, fell on her back and ruptured the terminal ileum Occasionally, however, the viscera lying directly beneath the point of trauma escape injury and the force of the blow is carried over to some other portion of the abdomen and expends itself upon a viscus less able to withstand the compression and disrupting effects of trauma The liver is commonly injured by a crushing blow received in the upper abdomen When the capsule of the liver is broken, the hepatic tissue offers slight resistance to fracture Fractures of the right lobe of the liver are about eight times more frequent than injury of the smaller left lobe Rupture of the gall bladder or common bile duct are uncommon injuries The spleen being a vascular organ fractures readily when important vessels are torn the blood loss may be severe Delayed hemorrhage attending splenic injury may sometimes come on a week or even a month later, and frequently presents a complication more dangerous than the original injury Isolated injury of the mesenteric or omental vessels may occur or may accompany any of the injuries already mentioned Isolated injury of the pancreas is quite unusual and occurs usually from severe blows in the epigastrium, as from the kick of a horse

Any of the large blood vessels traversing the abdomen such as the aorta, the inferior vena cava or the iliac vessels, as well as the vessels which supply the abdominal viscera, may be injured in either blunt or penetrating types of trauma

What Viscera Are Injured?

The scope of this presentation does not warrant going into any detail concerning the identification of the particular type of injury present The general considerations discussed previously in the chapter on diagnosis of acute abdominal disorders, when integrated in the light of where the trauma was inflicted upon the abdomen, the nature of the trauma, the functional disturbance, the physical findings and the two x ray observations mentioned viz a "scout" film and one in the erect posture, serve to afford quite satisfactory orientation concerning the probable pathological nature of the injury

In the experience of the writer, liver injury has not been associated with bradycardia as described by Finsterer Tenderness and normal dullness or percussion over the usual course of the ascending colon in injuries of the liver and over the descending colon in splenic injury are usual Frequently an intraperitoneal hematoma may be palpated or identified by percussion Kidney injuries may be identified by the presence of blood in the urine and if the local bleeding is great, by the palpation of a mass which may be felt both by a palpating hand in the loin as well as beneath the anterior abdominal wall Bladder injuries are to be recognized in the difficulty of passing urine, the appearance of blood in the urine or failure to recover fluid injected into the bladder Intravenous urograms may be of value, as may be the injection of an opaque medium (silver iodide) into the bladder in the recognition of kidney and bladder injury It is to be remembered that, following the passage of a catheter

into the bladder when intraperitoneal rupture is present, air may make its way into the peritoneal cavity and be visualized beneath the diaphragm on the film in the erect posture Perforation of stomach and intestinal canal are to be recognized in the presence of *free gas* below the diaphragm Perforation of the small intestine is not accompanied by the escape of enough gas early, as a rule, to permit recognition of a gas bubble beneath the diaphragm Gas is usually present in sufficient quantity in both the stomach and colon to cause it to accumulate beneath the diaphragm in sufficient amount to be recognized when a complete tear or perforation of the wall of the stomach or colon is present Gas can not be visualized usually in the small intestine normally, and unless the bowel is distended, it may take some considerable period of time for sufficient gas to escape following perforation of the small intestine, to cause a collection large enough to be seen beneath the diaphragm

The Treatment of Abdominal Injuries

Penetrating injuries The important matter to decide is whether operation is in order or whether the patient may be treated conservatively In perforating injuries whether by a bullet stab or other perforating object, operative intervention is almost invariably to be done as quickly as conveniently can be done for in the majority of instances a segment of the numerous twists and loops of the gastro intestinal canal is likely to be perforated, and as is apparent the time factor is very significant in determining the outcome The sooner the perforation is closed by suture the better As long ago as 1884 Parkes showed by shooting into the peritoneal cavities of dogs that spillage occurred almost invariably directly upon the infliction of the wound and perforation of the small intestine was usually present

Perforation of the stomach is least hazardous, and especially when the stomach is empty Bergh, Bowers and Wangensteen (1937) found that the stomach of the dog cat and other laboratory animals could be perforated, and without closure of the perforation recovery would occur in about 85 per cent of instances if the stomach were *empty* at the time of perforation If on the contrary food was present in the stomach at the time of perforation, the mortality without closure of the perforation was 88 per cent The state of alimentation does not affect the outcome so significantly in intestinal injuries Because of the acidity of the gastric juice, tears of the stomach afford a much more hopeful outlook than do similar injuries in the intestine Whereas, one might reasonably expect the greatest hazard from ruptures of the colon the greatest risk is run apparently by patients who have perforations in the terminal reaches of the ileum

When George Makins returned from the Boer war in 1901 he wrote a monograph advising the conservative treatment of perforating wounds of the abdomen It is to be recalled however that a type of itinerant warfare was pursued there which did not permit of the establishment of bases at which emergency operations could be done well Similarly, Nicholas Senn, in writing of his experience in the siege of Santiago in the Spanish American War, came to a conclusion similar to Makins' Be it

ever said, therefore, to the great credit of American surgery, that when President McKinley was shot through the upper abdomen at Buffalo at the Pan-American Exposition in September, 1901, the surgeons in charge operated immediately and closed the perforation in the anterior and posterior walls of the stomach The outcome was unfortunate, but even today a similar outcome might have followed the extensive damage done by the bullet in the retroperitoneal space Recent reports attest the hazard of such penetrating injury in the retroperitoneal tissue Following the shooting of President Garfield in 1881, Marion Sims was prompted to write a dissertation upon bullet wounds of the abdomen, in which he advocated early operative intervention In his prediction that, with early operative closure, intestinal perforation would no longer be very hazardous, he did not reckon adequately with the bacterial content of the bowel Cushing and Livingood and Kendall in epoch making papers, have pointed out the dangers of peritoneal contamination with intestinal content Until we come upon some pharmacological or immunological means of dealing adequately with the menace of escape of intestinal content, the mortality will probably continue to be lamentably high Not enough information is available to indicate yet whether the local implantation of sulfathiazole to be described subsequently, will affect the issue materially Even as late as the beginning of World War I, we find well recognized surgeons on both sides engaged in the conflict, advocating conservative treatment of perforating gun shot wounds of the abdomen Let any one who still doubts the validity of operation read the illuminating report by Enderlen and Sauerbruch in which the superiority of the immediate operative attack is unequivocally shown Closure of perforations, on the whole when feasible, is a better plan than intestinal resection

Blunt trauma When dealing with injuries in which the gastro intestinal canal is not perforated the need for operation is not so urgent To be certain, a torn bladder should be sutured as quickly as possible Experience has demonstrated however, that a damaged kidney may be managed conservatively with greater safety to the patient than by operation unless the bleeding is so severe as to demand operative intervention, in which event the risk also is great This experience with the treatment of renal injuries suggested a trial of the same means in dealing with tears of the liver and the spleen Over a period of more than 10 years, suspected injuries of liver of spleen, unless bleeding has been progressive have been treated conservatively in this clinic In subcutaneous injuries by blunt force, the great risk in conservative management is rupture of the intestine In fracture of the liver or spleen we operate rarely and almost invariably treat the patient expectantly, keeping close watch on the blood pressure and pulse rate In instances of subcutaneous injury, in which it is felt that the probable injury is that of liver or spleen, the appearance of tender areas remote from the site of injury should be looked upon with suspicion In the main, operation should be done in all such instances, for a tear in the mesentery or a perforation of the small bowel may be present Experience with the non operative treatment of bullet wounds of the lung

lends support also to the practice of dealing conservatively with bleeding from intraperitoneal solid viscera Many surgeons engaged in World War I had an opportunity to satisfy themselves that the conservative plan, on the whole, was safest in such instances

To be certain in a State University Hospital which draws its injured from varying portions of a large territory, the instances in which the intraperitoneal hemorrhage accompanying abdominal injury has been great, have probably been largely eliminated Some have died on the spot where the injury was received from a tear of important blood vessels, such as mesenteric vessels portal vein, or the vena cava, or even the aorta or some of its branches In the obviously ill patients with complex types of injury, including concomitant chest and head wounds or serious injury *to the extremities*, in the presence of concurrent suspected fractures of spleen and liver, it has been found wise to treat such patients conservatively These observations have made it appear even more rational to treat isolated injuries of spleen or liver conservatively, unless a falling blood pressure denoted the continuance of loss of blood When operative intervention is undertaken for the control of such hemorrhage, the importance of adequate transfusion of blood both before and during the operation can not be stressed too much It should be remembered that blood loss which causes shock is probably in the neighborhood of 1 000 cubic centimeters of blood in an average sized adult

There will by no means be uniform agreement among surgeons over the plan of conservative treatment of *abdominal injuries in the absence* of perforation of the gastro intestinal canal As one examines the literature he can not escape the impression that a more and more conservative attitude is becoming increasingly prevalent among surgeons generally, in dealing with injuries of solid intraperitoneal viscera The chief difficulty which hedges about the problem concerns largely being certain of *the exact nature of the injury* There is, admittedly, opportunity for being wrong—yet the price of satisfying one s curiosity by operation is too frequently bought at too big a premium, with an increased mortality It is well enough to say that abdominal exploration may be carried out in the chronic abdominal disorder without risk but unfortunately exploration is not so innocuous in the presence of abdominal hemorrhage which is being spontaneously controlled With the opening of the peritoneal cavity in such instances startling acceleration of the bleeding may occur

The shortcomings of the conservative management of subcutaneous abdominal injury are obvious and the surgeon who employs the method, must be vigilant not to stretch its use beyond reasonable indications Adequate blood replacement in all cases of hemorrhage before operation is mandatory In all penetrating or perforating types of injury, early operation is in order

The agencies which underlie acute abdominal afflictions are essentially (1) perforation (2) obstruction (3) inflammation, (4) hemorrhage and (5) injury The ultimate consequences of these factors have some effects in common

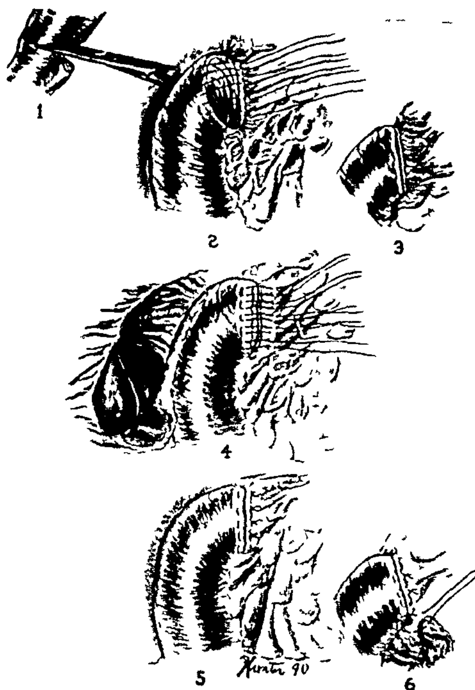


FIG 31—Closure of the duodenum in the surgical management of massive hemorrhage from bleeding duodenal ulcer The dissection and separation of the medial (posterior) duodenal wall from the pancreas is the first step This dissection succeeds in disclosing a perforation in the posterior duodenal wall in massive hemorrhage The anterior duodenal wall is then cut across totally with scissors as indicated in 1 and the bleeding vessel is ligated In 2 is shown the placement of interrupted Halsted mattress sutures of fine silk across the open end of the duodenum None are tied till all are placed The duodenal walls are approximated as shown in 3 when the

B HEMORRHAGE

The greatest immediate risk to life is in the rupture of a large blood vessel which traverses the abdomen or supplies one of the intraperitoneal viscera Such an extraordinary accident is directly fatal usually and is rarely susceptible of treatment Many of the lesser hemorrhages, such as those caused by tears of the liver or spleen secondary to trauma, do not give rise to serious loss of blood and may be repaired spontaneously without the intervention of the surgeon Continued bleeding in such instances is best reflected in an extension of the signs of peritoneal irritation and a mounting pulse rate these constitute indications for operation Hemorrhage occasioned by tears of solid intraperitoneal viscera are not *per se* indications for operation Traumatic bleeding from mesenteric blood vessels, however, demands early operative relief, not alone on account of loss of blood but even more because of the threatened loss of viability of the gut The very possibility for occurrence of this sort indicates the danger which lurks in the non operative treatment of certain types of abdominal injury, unless cases are carefully observed and individualized No blanket rule can be unfolded which will cover every case Intraperitoneal bleeding caused by an ectopic pregnancy in a Fallopian tube demands removal of this hazard as soon as its presence can be established definitely Bleeding from a duodenal or gastric ulcer occurs into the lumen of the alimentary canal and in consequence does not give rise to pain and tenderness common to all intraperitoneal hemorrhages As a rule, bleeding ulcers are best managed conservatively and a favorable issue usually attends supportive treatment Careful scrutiny of hospital as well as postmortem records however indicates that fatal hemorrhages from this source are more frequent than is believed generally In the presence of continued bleeding and a rapid pulse, despite several transfusions of blood operation is in order The difficult task of finding and dealing adequately with the bleeding in instances demanding operation is obvious

Accepted practice has been to regard massive hemorrhage from an ulcer as a medical problem and to invoke operation only for the occasional case Finsterer (1936) has been long an ardent advocate of operative intervention for the control of active bleeding More recently Gordon Taylor (1937) of London and Allen (1933) of Boston have advocated a more aggressive surgical attitude toward the patient who is bleeding actively from an ulcer Too many lives are lost through the *laissez faire* policy Hemorrhage from ulcer is undoubtedly, one of the few sources of active loss of blood from the body for which the conservative plan of management is advocated The difficulty lies, however in the formidable character of the operative intervention necessary to stop the bleeding

sutures are tied This closure is by no means as satisfactory as that obtained with the v Petz clips and silk suture inversion when there is no posterior wall perforation However when reinforced as shown in 4 5 and 6 thereby burying the closed duodenal end in the pancreatic capsule a satisfactory closure usually can be obtained even in difficult cases Particular note is to be taken of the manner of insuring a closed space on the posterior duodenal wall (6) This is a most important item in the procedure Such a suture is placed at the upper end as well

Yet, with adequate blood replacement, prior to and during operation and with satisfactory ligature of the bleeding vessel—a procedure which demands, usually, frank exposure of the ulcer, massive hemorrhage, threatening life, can be dealt with successfully by surgical means A number of studies have shown that, the mortality of medical management of massive hemorrhage from bleeding ulcer is in the neighborhood of 10 per cent A goodly number of these patients, who will die, unless bleeding is stopped effectually, can be salvaged by timely operation The experience of this clinic, in the surgical management of massive hemorrhage, has been very gratifying and has been reported elsewhere (1940)

It has been the writer s practice to perform gastric resection at the same time The importance of acid in the genesis of ulcer, has been established now beyond question Once the bleeding is stopped effectively, the operation is withstood The surgeon who undertakes these operations must *stop* the bleeding, he must learn also *how* to close the duodenum satisfactorily (the usual source of the bleeding), under most trying circumstances

C PERFORATION

Apart from potentially fatal hemorrhages, perforation of the gastro intestinal tract involves the greatest risk to life Because of its microbic character, breaks in the continuity of the alimentary canal must be considered among the most formidable and mischievous of abdominal catastrophes The most fundamental principle of action in the treatment of acute abdominal lesions is that perforations of the gastro intestinal tract demand immediate closure Recovery without suture of the defect is decidedly unusual This guiding rule obtains whether the perforation be the result of blunt trauma, a bullet wound, or a perforated ulcer Perforations of the stomach and duodenum, if closed early, have a favorable outlook, breaks in the continuity of the lower reaches of the small intestine, and colon, no matter how quickly closed, always take a large toll of life Allusion was made above to how well unclosed perforation of the stomach was withstood by laboratory animals, if the stomach were empty at the time of perforation When, however, perforation of the empty stomach is made through an area of inflammation, produced by previous local injection of a sclerosing agent, to imitate the situation, which obtains frequently in perforated ulcer spontaneous closure occurs rarely Apart from early and satisfactory closure of a perforated ulcer, the items which affect the issue in an important manner are 1) The state of alimentation at the time of perforation, 2) The size of the perforation and 3) The physical condition of the patient

It is proper to state here, that, perforation of an ulcer is not attended by shock, though prostration may be severe Shock with quickening of the pulse and depression of the arterial blood pressure, is a sign of hemorrhage

D OBSTRUCTIONS

No uniform rule can be established concerning the manner of dealing with obstructions In the main, it may be said that the sequelae which

attend the obstruction determine the choice of procedure Appendicular obstruction which makes of the appendix a potential closed loop with the attendant dangers of perforation, inherent in all closed intestinal loops, dictates early removal The importance of obstruction in bringing about perforation of the appendix has been well established The secretory capacity of the appendix (1 to 3 cc of fluid a day) accounts for this behavior (Wangensteen & Dennis 1939) Obstruction of the gallbladder may give rise to infection but perforation is not nearly as likely as in the intestinal canal, owing to the absence of normal bacterial flora and an active intrinsic secretory mechanism Practice has established adequately the rationale of the conservative, non operative policy in the treatment of most obstructions and infections of the gallbladder that operative intervention will be necessary in some instances scarcely needs elaboration Because operative intervention early in acute biliary colic has been compatible with relative safety some would urge cholecystectomy early in biliary colic as is regularly advised in appendicitis, unmindful apparently of the fact that appendicular obstruction is far more treacherous than is obstruction of the gallbladder It is the particular purpose of this work to define the guiding principles in the management of bowel obstruction Whether operative intervention is necessary in urinary tract obstructions will be decided by the grade of interference with urinary flow Complete obstruction, it is obvious necessitates removal or circumvention of the block to save life when the arrest is bilateral and complete and to preserve the function of the kidney in unilateral obstructions Barriers to venous outflow from organs as occur in torsion of bowel or ovary, demand uniformly early operative intervention to minimize blood loss and to obviate the effect of an obstructed circulation, on normal tissues

E INFLAMMATION

Primary inflammations of intraperitoneal viscera which command the urgent attention of the surgeon are not many Those infections which demand operative relief are, in the main probably conditioned by obstruction, e g appendicitis and cholecystitis In the kidney the full significance of this statement is more readily apparent The pyogenic infections of the kidney, which are susceptible of relief by surgery are those due to obstruction operation save for removal of the kidney has little to offer patients with pyelitis or pyelonephritis of pyogenic but non obstructive origin Some of the first lessons learned concerning the value of conservatism in the treatment of intraperitoneal infections were gained in the management of gonorrheal salpingitis It is now universal practice to treat acute infections of this nature without operation The futility of treating puerperal infections by operation is also well known

Surgeons must recognize their limitations in dealing with inflammation There are essentially only two indications for operative intervention in the treatment of infection (1) to prophylactically prevent extension of inflammation from a small focus into a large space—which is probably best exemplified by the removal of an acutely obstructed appendix to

Yet, with adequate blood replacement, prior to and during operation, and with *satisfactory* ligature of the bleeding vessel—a procedure which demands, usually, frank exposure of the ulcer, massive hemorrhage, threatening life, can be dealt with successfully by surgical means A number of studies have shown that, the mortality of medical management of massive hemorrhage from bleeding ulcer is in the neighborhood of 10 per cent A goodly number of these patients, who will die, *unless bleeding is stopped* effectually, can be salvaged by timely operation The experience of this clinic, in the surgical management of massive hemorrhage, has been very gratifying and has been reported elsewhere (1940)

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a liberal portion finds its way into the distal reaches of an inactive bowel, distension occurs in consequence, absorption is interfered with and the familiar picture of a ballooned bowel, just as effectually blocked as by a mechanical obstacle, dominates the scene.

This frequent occurrence in peritonitis has lent the impression that if intestinal distension can be avoided the battle is won. With employment of continuous suction applied to an indwelling duodenal tube from the start (before distension occurs) in peritoneal infections, distension can be prevented almost uniformly. Enough experience has now been had with the treatment of peritonitis with the aid of this auxiliary, to indicate that, infections in the peritoneum are no exception to those elsewhere in the body. Peritonitis, to be sure, can run a fatal course in the absence of distension. That distension may affect peritoneal infection unfavorably is apparent; that ileus is the chief cause of death in peritonitis is to be denied. This complication of distension in peritonitis can, as a rule, now be dealt with adequately by relatively simple means.

The use of sulfonamides in the treatment of peritonitis will show, undoubtedly, some improvement in the results. Up until now, most of the results have concerned the use of sulphanilamide in the management of peritonitis accompanying ruptures of the appendix. Similarly, sulfonamides have been administered prophylactically to minimize the hazards of peritonitis attending operation upon the large bowel. In this clinic, the local implantation of sulfathiazole at the time of operation, is favored. This subject will be discussed at greater length subsequently. The prevention of peritonitis has proved considerably more successful than its treatment. Farr and McFayden (1940) have found the administration of amino acids to children suffering from pneumococcal peritonitis to be an important item in the reduction of mortality.

The employment of continuous suction applied to an inlying duodenal tube widens the scope of the conservative treatment of acute abdominal disorders. Suspension of normal intestinal activity accompanies, in some measure every intraperitoneal accident in which fluid escapes into the peritoneal cavity. Operative relief was often as urgently compelled by the presence or anticipated occurrence of ileus as by the causative lesion. With a readily available and even more effectual agency of dealing with the accompanying ileus than by operation, the necessity for operative intervention is to be determined solely by the nature of the disorder.

The excursions of the diaphragm are also automatically restricted in peritonitis and particularly in affections of the upper portion of the peritoneal cavity. Complete cessation of its motion, however occurs rarely. The secretion of fluid by the serosal cells of the peritoneum, in response to the presence of the irritant, furnishes another means of bacterial escape to spread the infection. From the site at which the bacteria made their entry into the peritoneal cavity, they are transported passively through this means far beyond the initial confines of the portal of admission. If these latter two factors could be as effectually dealt with, as the ileus problem in peritonitis many more victories would be won daily in our conflict with peritonitis.

obviate peritonitis, (2) the chief indication for operation in infection is to drain an abscess It is becoming more and more appreciated that when a surgeon operates for the relief of infection *before* pus has formed, he has not only done an unnecessary operation, but has probably also done actual harm No longer does one operate upon an abscess of the brain or lung as soon as the diagnosis is made On the contrary, signs of localization are awaited The surgeon can not localize an infection, the resistance of the patient must overcome the invading organisms The surgeon can only do harm by interfering before the tissues have localized the infection and before pus is present The role of the surgeon in the management of inflammation may be regarded primarily, therefore, as that of a *pus evacuator* Whereas an antiseptic may be placed on the skin and the surgeon may invade and explore aseptically almost any organ or tissue of the body with impunity, when infection is present, he has no remedy to hold out to the patient, not known to the pre Listerian era What specific help have aggressive surgical measures lent patients with cellulitis or a pyogenic blood stream infection? Fortunately, for both patients and surgeons, the sulfonamides are accomplishing miracles in the management of some infections—accomplishments that were only dreams before the discovery of these chemotherapeutic agents

Rest remains still the chief therapeutic adjunct of the surgeon in treating infections in which no localization has occurred In an extremity, plaster of Paris casts may be applied, with appropriate windows cut in to permit of inspection of the part under observation Instances have come under the supervision of the writer where amputation has been weighed as the therapeutic expedient most likely to save life—instances in which fever and infection have continued unabated despite generous incision in which instances, immobilization in a plaster cast of the extremity concerned and enough of the body trunk to bring about absolute rest, quickly brought about improvement and relief from pain Incisions in the absence of collections of pus are unwarranted

This scheme, which was invoked by V Bergman (1874) and employed by Dennis (1884) with considerable success in the management of compound fractures, was advocated ardently by Orr (1927) after the first world war as a satisfactory plan for the management of osteomyelitis and compound injuries It has been employed in this surgical clinic with considerable satisfaction since 1934 It found renewed favor in the war in Spain (Trueta) as well as in World War II

In the peritoneal cavity, three factors operate to defeat the walling off process with which the peritoneum strives to combat infection All have to do with motion, the first two with active movement and the other with passive motion, (1) the activity of the bowel (2) the excursions of the diaphragm, and (3) the secretion of fluid into the peritoneal cavity In part the organism safeguards itself against the danger of the former by suspending intestinal motility There are, however several liters of fluid secreted daily into the upper reaches of the intestinal canal which must be disposed of With the cessation of intestinal activity some of this fluid can be gotten rid of by vomiting, together with swallowed air, however,

a liberal portion finds its way into the distal reaches of an inactive bowel, distension occurs in consequence, absorption is interfered with and the familiar picture of a ballooned bowel, just as effectually blocked as by a mechanical obstacle, dominates the scene.

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F PANCREATIC NECROSIS

What the responsible etiological factors are in cases of acute pancreatic necrosis have not been generally agreed upon, though it is known that different types of agencies, especially when operating together, may produce the disease The surgical treatment of the condition appears, to the writer to be entirely non specific There have been essentially three things which surgeons have done in its surgical management (1) Drain the peritoneal cavity and remove in as far as practical the intraperitoneal collection of fluid, (2) drain the biliary tract by cholecystostomy or choledochostomy, and (3) tamponade of the pancreas

Whereas the mechanism which causes pancreatic necrosis may not be well understood, the cause of death can with some assurance be said to be *autodigestion of the pancreas* The peritoneal fluid appears to be innocuous on animal innoculation *If the element of infection is an important causative factor*, it would appear that in the presence of considerable free fluid in the peritoneum, the insertion of gauze packing or other drains to the pancreas would be a useless agency in delimiting the process Drainage *of the biliary tract in pancreatic necrosis is indicated when an obstruction* at the ampulla makes of the choledochus and duct of Wirsung a common channel, permitting the regurgitation of bile into the pancreatic duct In instances of pancreatic apoplexy with the formation of a large retrogastric hematoma, operation may be employed as a means of staunching the bleeding Such bleeding however, is but a reflection of the extent of the necrosis, and operation in such instances is usually a futile gesture

Except in the presence of ampullary obstruction, none of these operative procedures appear to constitute a direct or helpful attack upon the disease The *effort indicated in pancreatic necrosis* is an attempt at inhibiting the conversion of trypsinogen into the active ferment, trypsin, within the pancreas To be certain, the execution of this design is difficult, but it is reasonable that operations which accomplish no specific purpose should be withheld *Starvation and partial* removal of the normal physiological activator of trypsinogen succus entericus, by suction applied to an inlying duodenal tube do not encumber the patient with an added serious burden as does an operation, which fails of specific accomplishment Morton (1940) has advocated and employed, with some success, *irradiation with x rays* as a means of inhibiting pancreatic secretion in the management of pancreatic necrosis

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Chapter V

ADJUVANT (INDIRECT) MEASURES IN THE TREATMENT OF BOWEL OBSTRUCTION

Once the diagnosis of intestinal obstruction is established, the most important question to decide is what agency should be employed in its relief Of the available therapeutic procedures, only two affect the obstructive process directly, viz, operation and suction applied to an inlying duodenal tube The other remedial measures of merit in the management of obstruction are essentially supportive agencies and are of particular value where a consequence of obstruction arises which calls for their use, these are infusion of saline solution, transfusions of blood and plasma and inhalation of high concentrations of oxygen (Fine and associates 1935 1936) The former is a great vitalizer in many states, but when vomiting has been prominent the liberal administration of saline solution is mandatory So similarly with transfusion of blood, it may be used to advantage frequently without strict indication In strangulating types of obstruction where the patient's pulse is rapid because of loss of blood into the infarcted segment, blood transfusion acts like a restorative Similarly, where a high grade of distension has diminished the effective circulatory blood volume transfusion of plasma is an expedient of value In those instances of strangulating obstruction in which the pulse is rapid because the viability of the bowel wall is lost and transperitoneal absorption from the lumen is occurring, transfusion is a laudable but impotent gesture

Agents which enhance the contractile activity of the bowel have no place in the management of mechanical obstructions Their role in the treatment of the distension of physiological obstruction will be subsequently discussed It may here well be noted that the remedial measures which have established their worth in the relief of obstruction ask only a passive role of the bowel

It will be the purpose of this section to define what the therapeutic values of these agents are, what indications denote their employment, what their shortcomings are, together with an account of what may be expected of each agent

A SALINE SOLUTION

The success of saline solution in prolonging the lives of dogs with high obstruction afforded clinicians considerable hope that it would prove a great boon to patients with bowel obstruction As has already been pointed out however saline solution even in dogs exerts the virtues of a specific only in high obstructions, in the lower varieties, it exhibits no special merit Most obstructions observed clinically occur relatively low in the intestine In consequence very little specific help is to be expected in bowel obstruction by the administration of saline solution alone In pyloric obstructions attending duodenal ulcer and in the temporary obstructions occasionally observed at the stoma after gastrojejunostomy

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Chapter V

ADJUVANT (INDIRECT) MEASURES IN THE TREATMENT OF BOWEL OBSTRUCTION

Once the diagnosis of intestinal obstruction is established, the most important question to decide is what agency should be employed in its relief Of the available therapeutic procedures, only two affect the obstructive process directly viz , operation and suction applied to an inlying duodenal tube The other remedial measures of merit in the management of obstruction are essentially supportive agencies and are of particular value where a consequence of obstruction arises which calls for their use, these are infusion of saline solution, transfusions of blood and plasma and inhalation of high concentrations of oxygen (Fine and associates 1935 1936) The former is a great vitalizer in many states, but when vomiting has been prominent, the liberal administration of saline solution is mandatory So similarly with transfusion of blood it may be used to advantage frequently without strict indication In strangulating types of obstruction where the patient's pulse is rapid because of loss of blood into the infarcted segment blood transfusion acts like a restorative Similarly, where a high grade of distension has diminished the effective circulatory blood volume transfusion of plasma is an expedient of value In those instances of strangulating obstruction in which the pulse is rapid because the viability of the bowel wall is lost and transperitoneal absorption from the lumen is occurring transfusion is a laudable but impotent gesture

Agents which enhance the contractile activity of the bowel have no place in the management of mechanical obstructions Their role in the treatment of the distension of physiological obstruction will be subsequently discussed It may here well be noted that the remedial measures which have established their worth in the relief of obstruction ask only a passive role of the bowel

It will be the purpose of this section to define what the therapeutic values of these agents are what indications denote their employment, what their shortcomings are, together with an account of what may be expected of each agent

A SALINE SOLUTION

The success of saline solution in prolonging the lives of dogs with high obstruction afforded clinicians considerable hope that it would prove a great boon to patients with bowel obstruction As has already been pointed out, however saline solution even in dogs exerts the virtues of a specific only in high obstructions, in the lower varieties, it exhibits no special merit Most obstructions observed clinically occur relatively low in the intestine In consequence, very little specific help is to be expected in bowel obstruction by the administration of saline solution alone In pyloric obstructions attending duodenal ulcer and in the temporary obstructions occasionally observed at the stoma after gastrojejunostomy

or gastric resection, the free administration of saline solution has proved of great value Whereas the dehydration occurring in bowel obstruction is satisfactorily combated by saline solution, it exerts no real favorable influence on the course of the obstruction

Although no specific improvement attends the employment of saline solution in many obstructions, nevertheless, the importance of this agent in bettering the patient's general condition is not to be underrated It has been stated previously that patients with bowel obstruction have oliguria In high obstructions with profuse vomiting attended by the loss of considerable fluids and electrolytes, oliguria and even anuria may be observed When the blood chlorides fall to a low level, no sodium chloride is available for excretion and urine is not put out When the depleted chlorides are replenished and fluid is given, the excretion of urine begins again In low obstructions, interference with absorption and lack of a normal fluid intake are responsible largely for the oliguria observed The free administration of saline solution restores the general bodily state of the patient

Enough saline solution should be given to insure a daily urine output of 700 to 1000 cubic centimeters in which the presence of a total of about 3 grams sodium chloride may be demonstrated Paine and Armstrong (1939) point out that sodium chloride is a threshold substance and amounts given, beyond the body needs, are excreted The daily excretion of a satisfactory quantity of urine constitutes a reliable index of the presence of a normal tissue fluid balance, and the excretion of 3 grams of sodium chloride daily in the urine suggests that the patient is also in satisfactory sodium chloride balance In low obstructions attended by great distention, the too liberal administration of saline solution may result in greater accumulation of fluid within the bowel, for Bayliss and Starling (1894) have shown that the intravenous administration of saline solution increases greatly the capillary pressure in the intestinal vessels attended by a similar increase in portal pressure and flow in lymph In the presence of a falling blood pressure, Blalock, Beard and Thuss (1932) and accompanying local injury to the intestine Beard and Blalock (1932) found that intravenous injections of glucose or saline solutions were attended by an increase of loss of plasma protein through the capillary wall

Sodium chloride balance The most accurate index of the sodium chloride balance is determination of the plasma chloride level in the blood Normal values for sodium chloride in the plasma run from 560 to 600 mg per cent Coller and his associates (1938) have suggested that, for each 100 mg per cent that the plasma chlorides need to be raised, to reach the normal minimum value of 560 mm per cent the patient be given 5 gram of sodium chloride per kilo of body weight In a patient weighing 70 kilos and in whom the plasma chloride value is found to be 460 mg per cent, the patient will need $560 - 460 = 100 \times 5 \times 70 = 35$ grams of sodium chloride to bring the value up to the normal of 560 mg per cent These predicted calculated values coincide quite accurately with clinical trials Overchlorination of patients which results from the too liberal use of saline solution, causes salt retention and edema For each 9 grams of salt

administered, beyond the body needs, if the excess salt is not eliminated in the urine or by sweating 1,000 cc of fluid accumulates in the extracellular fluid spaces

Status of hydration and water requirements The status of hydration of the patient can not be determined as accurately as the status of chlorination In the main, however, thirst of the patient, dryness of the skin and tissue turgor are satisfactory indices of the status of hydration In patients presenting no disturbance in fluid balance, on admission to hospital, the status of hydration may be maintained with considerable precision during the postoperative period by weighing the patient (page 243) Obstructed patients who give a story of considerable vomiting, and, who present obvious evidences of fluid loss should have early and adequate replacement of such losses Coller and Maddock (1940) have suggested the following guides for orientation of the surgeon in the determination of the amount of fluid required daily for 24 hour periods by surgical patients

TABLE XV—WATER REQUIREMENTS OF SURGICAL PATIENTS

A The uncomplicated surgical case	
1 Water for urine—water necessary to provide a satisfactory daily output of specific gravity in the optimal range of 1.015	1000 cc
2 Water for vaporization—water necessary to replace fluid lost by vaporization from skin and lungs	1000 cc to 1500 cc
TOTAL	2000 cc to 2500 cc
B For the complicated case (fever hyperthyroidism hot humid weather and intestinal obstruction)	
1 Water for urine	1000 cc to 1500 cc
2 Water for vaporization	2000 cc
3 Water necessary to replace fluid lost by vomiting aspiration from inlying duodenal tube drainage from biliary and intestinal fistulae diarrhea blood loss and exudation from areas of increased capillary permeability (areas of inflammation or threatened loss of viability)	X variable
TOTAL	3500 cc + variable X

Item 3 in patients with obstruction of the small intestine is usually a consideration of the greatest importance Coller and Maddock believe that patients who present *manifest* evidences of dehydration have lost 6 per cent of their body weight In a patient weighing 70 kilos 4200 cc of water would have to be given under item 3 to replace the 6 per cent weight loss owing to vomiting and lack of fluid intake by a patient with obstruction high in the small intestine

The excretion of a satisfactory amount of urine with a specific gravity within the normal range (1 012 to 1 020) gives adequate assurance that the fluid requirement of the patient has been met There are hazards of overhydration, as well as of underhydration, particularly in the old patient, who has a poor cardiac reserve Some of the factors bearing on this issue, such as the quantity quality, and route of fluid, will be discussed subsequently in Chapter IX on Post operative Treatment

Water of vaporization is divided between skin and lung losses. Ordinarily, the losses of water through *renal and extrarenal channels are* divided equally, about a liter being lost through each (Gregersen 1938). Adolph (1933) estimates the loss of water by vaporization from the lungs as constituting about 30 per cent of the extrarenal losses (see Table I, page 9). The insensible cutaneous loss of water and that lost by respiration are continuous processes which go forward at an approximately constant rate. Loss of water through the kidneys and the sweat glands fluctuates normally, within very wide ranges.

In obstructed patients, presenting evidences of dehydration, the intravenous administration of 5 per cent glucose in saline solution is in order. When a satisfactory urine flow has been established, the subcutaneous route may supplant, in part, intravenous injections of saline solution. Addition of glucose to the saline solution helps to combat the ketosis which accompanies starvation. The problem of meeting the caloric and nitrogen needs of the patient, in addition to the generally recognized water and electrolyte requirements, will be discussed at length subsequently (Chapter IX).

B. BLOOD AND PLASMA TRANSFUSIONS

The *blood loss factor in all strangulating obstructions may be a consideration* of some moment. Into a gut, in which the wall is the seat of hemorrhagic infarction, considerable blood may be lost, especially if that segment be long. Blood is lost into the lumen as well as into the wall of the bowel. In volvulus, intussusception, strangulated hernias, adhesive obstructions with compromise of the blood flow and mesenteric thrombosis the blood loss factor may be a significant item. Whereas blood volume reductions of 20 per cent have been described by Herrin and Meek in dogs with Thiry fistulas artificially distended to simulate the condition present in obstruction, the actual blood loss is not great, and clinical trial demonstrates the futility of expecting a *favorable influence* upon the course of simple obstruction by replenishing the depleted blood volume, alone, whether with plasma or blood. However, in all simple obstructions accompanied by great distension, transfusion of blood or plasma proves to have value in that it meets the plasma loss factor satisfactorily. In chronic obstructions, in which the plasma proteins may be low because of prolonged inanition, transfusions of plasma are in order to repair this deficiency.

In any patient with a strangulating obstruction in whom the pulse is hurried or the blood pressure is at or near the shock level, the transfusion of blood or plasma is indicated. [illegible] more, in this clinic, plasma is
[illegible] idely in th [illegible] of shock and depleted protein
[illegible] of pla [illegible] that hemolytic reactions have
[illegible] ollow [illegible] evere shock attending blood
[illegible] of this [illegible] blood is superior to plasma
[illegible] ronic obstructions, in which
[illegible] f prolonged inanition,
[illegible]

In any patient with a strangulating obstruction in whom the pulse is hurried or the blood pressure is at or near the shock level the transfusion of blood and plasma is indicated

The following case illustrates well the occurrence of blood loss in a strangulating obstruction A female child of eighteen months was admitted to hospital with an invagination of the bowel of 72 hours' duration The pulse was feeble and extremely rapid, the rate being about 200 per minute No improvement attended the subcutaneous administration of 300 cubic centimeters of saline solution After being brought to the operating room, 500 cubic centimeters of saline solution was given intravenously without favorable effect upon the pulse, whereupon 300 cubic centimeters of citrated blood was administered through the same needle The pulse became stronger and slowed to 160 Ether was administered and a compound intussusception (entero enteric and ileocolic) was found and reduced The Meckel s diverticulum which constituted the apex of the intussusception was amputated The telescoped gut wall was thick and diffusely red, but fortunately, appeared to be viable The patient convalesced uneventfully Without adequate blood replacement, such a patient could not have been operated upon safely No patient with a strangulating obstruction in which the pulse is hurried should be *submitted to operation* without preliminary transfusion of blood or plasma in adequate amounts

C INHALATION OF HIGH CONCENTRATIONS OF OXYGEN

In 1936 Fine and his associates suggested that, inhalation of high *concentrations of oxygen would help to combat intestinal distension and that* this agency would prove useful in the treatment of mechanical as well as inhibitive paralytic types of ileus Fine s thesis is based on the relatively high tension of nitrogen present normally in the blood plasma Inasmuch as nitrogen constitutes roughly 80 per cent of air it is obvious that the *tension of nitrogen in the alveolar air will be*

$$80\% \text{ of } 760 \text{ mm Hg} - 47 \text{ mm Hg (water vapor pressure at } 37°)$$
$$80 \times 713 \text{ mm Hg} = 570 \text{ mm Hg}$$

By reducing materially the amount of nitrogen in the gas inhaled, by substituting oxygen for it, the tension of nitrogen in the alveolar air may be made to fall to zero In consequence, the nitrogen in the bowel may be caused to be given up from the intestinal lumen for exhalation by the lungs Wright (1939) states the solubility of the respiratory gases in 100 cc of plasma at 38° C and 760 mm Hg pressure is as follows CO_2 54 1 cc oxygen 2 3 cc and nitrogen 1 2 cc Despite this low coefficient of diffusion it is obvious that Fine s concept of transport of nitrogen across the intestinal mucosa from the lumen of the bowel is sound Nitrogen, despite the low coefficient of diffusion, constitutes 70 per cent of the gas in the obstructed bowel and it is apparent that, with the elapse of time, significant amounts of intestinal gas may be removed by this expedient Fine and his associates and Paine have demonstrated conclusively in the dog that established distensions accompanying mechanical obstructions may be influenced favorably by the inhalation of high concentrations of oxygen

In this clinic, however, the impression has been gained, that in order to be effective, this expedient must be accompanied by the use of suction applied to an indwelling duodenal tube, for, otherwise, one intestinal gas is probably replaced by swallowed increments of another gas

Paine and his associates (1941) who have given serious study to the general problem of influencing the absorption of gas from the intestine by the inhalation of high concentrations of oxygen have observed that, normal (unobstructed) dogs may be killed regularly by the uninterrupted administration of oxygen in concentrations above 70 per cent A severe inflammation is set up in the lungs and the dogs die of pulmonary edema In addition, necrosis in the liver occurs Paine has not, as yet, clarified how occasional interruptions may modify this serious potential complication of inhalation of high concentrations of oxygen in the management of intestinal distension It is to be noted further that Paine s observations have been made only on the dog Yet, his observations corroborate the old impression held by physiologists viz that inhalation of high concentrations of oxygen may cause desquamation of pulmonary epithelium

Lovelace (1941) has suggested recently that more than one atmosphere of pressure may be used to augment the rate of migration of intestinal gas across the intestinal epithelium It is obvious that this suggestion necessitates the use of special apparatus to avoid the hazards of employment of pressure greater than one atmosphere

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CHAPTER VI

DECOMPRESSION BY APPLICATION OF SUCTION TO DUODENAL TUBES IN OBSTRUCTION

A FACTORS SUGGESTING USE OF CONSERVATIVE DECOMPRESSION

FROM determinations made upon fluid escape occurring through an enterostomy tube from a gut obstructed by adhesions, it was observed frequently that, after an initial escape of small amounts of gas and fluid, the gut established again its own continuity with little or no subsequent drainage On the contrary, instances were observed in which the drainage was profuse and continued independent of the site at which the drainage vent had been established It was reasoned, therefore, that the continuance of profuse drainage following high jejunostomy or low enterostomy was dependent on the persistence of a high degree of obstruction, that minimal escape of gas or fluid through an enterostomy tube indicated that the obstructive mechanism must have relented

These observations suggested the possibility of decompressing the gut in certain instances of mechanical obstruction without operation The observations with relation to the fluid lost through an enterostomy have been extended since the employment of suction has been applied to an indwelling duodenal tube to include gas escape as well The impression first gained that the quantity and continuance of escape are correlated with the degree of the obstruction and not with the site at which the enterostomy was made have been borne out fully (Table XVI)

TABLE XVI — FLUID DRAINAGE THROUGH TUBE FOLLOWING ENTEROSTOMY FOR ACUTE INTESTINAL OBSTRUCTION

CASE I (Mrs E H)

Preoperative diagnosis Acute adhesive obstruction complete as indicated by Fig 26

Duration 4 days

Procedure Enterostomy in lower ileum

Postoperative day	Drainage through enterostomy tube (cc)
1	375
2	200
3	85
4	0
5	0

Outcome Satisfactory dismissed 21 days after operation

Comment Obstructing mechanism must have soon relented following the establishment of drainage

CASE II (Mrs C R)

[illegible]agnosis Partial ob truction due to adhe ive band

[illegible]s

[illegible]erostomy

TABLE XVI—FLUID DRAINAGE THROUGH TUBE FOLLOWING ENTEROSTOMY FOR ACUTE INTESTINAL OBSTRUCTION (*Continued*)

Po toperative day	Drainage through enterostomy tube (cc)
1	250
2	15
3	5
4	20
5	200
6	150
7	100
8	75
9	50
10	75
11	50
12	100

Outcome Recovery

CASE III (Mrs B Z)

Preoperative diagnosis Partial ob truction due to adhe ion
Duration 20 hours
Procedure Enterostomy

Po toperative day	Drainage through enterostomy tube (cc)
1	0
2	0
3	20
4	65
5	180
6	60

Outcome Recovery

CASE IV (Mr A M)

Preoperative diagno is Strangulating obstruction caused by adhe ive band
Duration 3 day
Procedure Exteriorization of 24 inches of gangrenous bowel in mid ileum Catheters placed in both proximal and distal ends

Postoperative day	Drainage through proximal catheter (cc)	
1	1700	
2	2450	
3	1500	
4	1700	
5	0	(e cape of fluid around catheter)
6	500	
7	400	

Outcome Recovery with succesful closure of fi tula 2 months later

CASE IV (Mr A M)—Second admis ion

Preoperative diagno is Strangulation ob truction cau ed by adhe ive bands
Duration 22 hours
Procedure Enterostomy 18 inches di tal to duodeno-jejunal angle with division of adhesive band Bowel viable

TABLE XXI.—FLUID DRAINAGE THROUGH TUBE FOLLOWING ENTEROSTOMY FOR ACUTE INTESTINAL OBSTRUCTION (*Continued*)

Postoperative day	Drainage through enterostomy tube (cc)
1	90
2	25
3	10
4	5
5	10
6	5

Outcome Recovery

Comment On first admission the fluid drainage represents the quantity lost through a complete fistula On the second admission though the enterostomy was high the drainage was slight in amount

These observations, made before suction applied to an indwelling duodenal tube was employed as an agency in the treatment of mechanical obstructions have been confirmed since, with the addition that simultaneous measurements of gaseous escape have been made as well In the main, the quantity of gas aspirated through an enterostomy catheter, like the amount of fluid drainage, is dependent largely on the grade of obstruction present The removal of a small amount of gas or fluid near the obstruction may be followed by spontaneous restoration of intestinal continuity In this connection, it is interesting to note that exteriorization of the lower ileum, in an unobstructed patient for removal of a carcinoma of the cecum, in accordance with Lahey's (1932) adaptation of the Bloch Paul Mikulicz operation, may be unattended by fluid or gaseous drainage initially for periods exceeding 24 hours in length This occurrence is owing no doubt, to the paretic effect of operation and anesthesia upon the bowel and is a factor that must be reckoned with in all operations directed at the relief of obstruction

An opportunity for trial of suction applied to a duodenal tube was afforded in the summer of 1931 in the instance of a seventy two year old lady admitted to hospital late at night with an obstruction of 72 hours' duration The patient was dehydrated badly and the systolic blood pressure was 80 millimeters of mercury The distension was considerable as revealed by the roentgenogram It was apparent also from the film that the entire small intestine was dilated Past experience had taught that saline solution alone did not improve materially the condition of such a patient as an operative risk and the hazard of relieving the obstruction by operation was quite obvious Not without a feeling of some timidity a duodenal tube was passed into the stomach and attached to a source of continuous mild suction Saline solution was administered subcutaneously and the foot of the patient's bed was elevated

The next morning the patient's condition was found to be improved notably Two hundred cubic centimeters of fluid and 800 cubic centimeters of gas had been aspirated during the night A film taken eight hours after the first showed marked reduction in distension After 40 hours suction the decompression was complete Because of the conjectured persistent nature of the obstruction (believed to be carcinoma of the cecum) operation was performed A stricture of the terminal ileum probably syphilitic



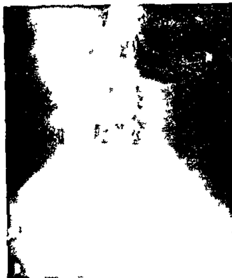




FIG 32—Decompression by suction applied to an indwelling duodenal tube in a high grade low ileal obstruction Mrs E J aged 72 (a) Radiograph of abdomen on admission to hospital 72 hours after onset of obstruction Moderate distension of entire small intestine is present the patient generally was in poor condition (b) After 8 hours suction during which time 200 cubic centimeters of fluid and 800 cubic centimeters of gas were aspirated (c) After 40 hours suction decompression is complete Because of the conjectured nature of the obstruction (thought probably to be *carcinoma* of the cecum) operation was done A stricture of the terminal ileum was found incised and invaginated into the *cecum* The patient recovered

in nature was found The stricture was divided in the longitudinal axis of the bowel the strictured area was invaginated into the cecum, and a proximal enterostomy was done, following which the patient convalesced uneventfully

The Rationale of Conservative Decompression

John Hunter is said to have related to Edward Jenner, "Try *the* experiment don t think ' Direct experimentation will probably always have an important place in all human activity Rationalization without recourse to analysis *of accepted* premises by direct experiment leads one into errors frequently, not often because the deductions are fallacious, but

rather because the premises themselves are invalid One occasionally finds himself saying, "Is not that quite obvious? Why didn't I think of that before?" If all the factual data bearing on the issue were available and known to the one attempting rationalizations, there would be little need for direct experiment Mathematicians and logicians then, who would take the time to become thoroughly acquainted with the subject under discussion, could deliver a satisfactory and accurate answer to any question propounded them

When, however, the result of experiment is conclusive and unequivocal, it may be rationalized readily and the significance of its constituent components may be properly appraised

As has been related previously, the chief sources of distension in the obstructed bowel are swallowed air and fluid dumped in at the gateway of the intestinal canal, viz, gastric and pancreatic juice bile, and succus entericus In the presence of high grade interference with the continuity of the bowel, regurgitation of the stagnant intestinal content into the stomach and upper reaches of the intestine is an invariable occurrence It is immediately apparent that as fluid and gas accumulate in the stomach they may be removed readily by intubation The mechanism of effectual decompression of the lower reaches of distended small intestine by this means, however, is not so obvious The small intestine of the adult is an elastic tube of about twenty or more feet in length The activity of the pyloric sphincter interrupts the continuity of the stomach and small intestine as a single simple tube Not uncommonly, however, this sphincter fails to present a physiologic block for decompression of the small intestine by a tube lying in the stomach Moreover it is found to be a distinct advantage, in influencing the distension favorably, to have the tube pass beyond the pylorus, well into the small intestine A catheter with a somewhat stiff tip appears to enter the duodenum more readily than the soft tube

In the intestine of the intact dog or in the human gut excised at necropsy, it may be demonstrated readily following the introduction of air or water into the intestine that the exertion of suction on one end is immediately appreciated in the same degree at the other end When, however, a mixture of gas and fluid is present, the difficulty well known to physicists whether dealing with rigid or elastic tubes comes into play In simple gaseous or fluid distension, the entire intestine may be decompressed almost at once When segments of gut are found alternately distended with gas and fluid, decompression will be effected only slowly

The Necessity for the Use of Suction

The alimentary canal is unique among the tubular organs and cavities of the body in that both gas and fluid are concomitantly present under normal conditions When the bowel is obstructed large accumulations of both fluid and gas are the rule It has been said occasionally that, an inlying duodenal tube will serve the desired ends equally as well as the addition of suction to the tube

The verity of such a contention may be submitted easily to experimental inquiry The efficacy of an inlying duodenal tube employed as a simple

siphon may be tested readily by measuring the fluid that drains away, no opportunity however is afforded for determining its worth in the removal of gases because of their escape By employing a Mariotte bottle for the collection of the gas aspirated, the efficiency of simple siphonage for the removal of gas may be determined also The construction of the bottle is such that the pressure of the atmosphere is always present at the end of the tube in which the fluid and gas are delivered by the duodenal tube from the stomach

By alternating siphonage and suction in patients who had been operated

TABLE XVII —QUANTITIES OF FLUID AND GAS REMOVED BY ALTERNATING SIPHONAGE AND SUCTION (Paine and Wangensteen 1933)

Time	Siphonage		Suction	
	Gas cc	Fluid cc	Gas cc	Fluid cc
4 hrs 30 min			750	50
8 hrs 30 min	25	175		
10 min			50	250
4 hrs 55 min	0	0		
10 min			500	200
1 hr 50 min	0	0		
10 min			0	0
3 hrs 55 min	0	0		
10 min			0	600
2 hrs 35 min	75	325		
10 min			800	600
5 hrs 50 min	0	0		
10 min			400	500
2 hrs 15 min		0		
10 min			200	400
2 hrs 25 min	0	0		
10 min			200	200

on for a variety of abdominal disorders, it was demonstrated readily that suction was considerably more effectual than siphonage (Paine and Wangensteen 1933) Frequently as much gas and fluid were aspirated in ten minutes when the duodenal tube was attached to a source of mild but continuous suction as had been aspirated in as many hours when the tube was attached to a Mariotte bottle acting as a simple siphon

The fluid and gas escape in a patient from whom the gallbladder had been removed, treated with alternating suction and siphonage as indicated in the accompanying table (Table XVII) may be considered as quite typical of the comparative efficacy of these two agents in providing for the removal of gas and fluid from the upper reaches of the intestinal canal and stomach by an inlying duodenal tube

Similarly x ray examinations made of the abdomen of patients with intestinal distension before and after the employment of siphonage and suction attest the greater efficiency of the latter in influencing the distension favorably



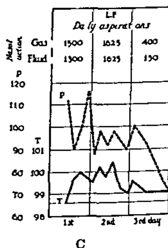


FIG 33—Decompression after three hours of suction in a complete jejunal ob truction L F a boy of 9 years (a) Radiograph of abdomen on admission after 48 hours of inte tinal colic and vomiting The ob truction concerns the upper third of the small intestine apparently and is complete no gas being vi ualized in the colon after the administration of evacuant enema (b) After 20 hours suction decompression is complete A film taken 3 hours after the commencement of suction indicated that the distension had been influenced favorably already To avoid any delusion concerning the existence of the obstruction explora tory laparotomy was done 15 days later An adhesive band was found binding the gut and its mesentery down to the posterior parietal peritoneum at about the location deduced from the initial film The band was divided and the patient was dismissed 14 days later (c) The graph indicates the pulse and temperature reaction during the time that suction was employed also the quantities of fluid and gas aspirated

As a matter of fact, this is what one would expect should happen, bear ing in mind the mechanics of siphonage The successful operation of a water siphon depends upon the existence of two vertical columns of fluid of unequal height connected at the top Both columns of water have the pressure of an atmosphere exerting itself on their lower ends, but since one column is longer and therefore heavier than the other it pulls the shorter column in its direction A negative pressure then obtains at the end of the shorter tube which equals in grams per square centimeter the difference in height of the two columns of water in centimeters If gas enters the system, the siphonage action ceases immediately since the dif-

ference in height of the two columns of water no longer exists A few bubbles of gas may pass through without interrupting the action of the siphon but a very small quantity (20 cubic centimeters) of gas will effectually interfere and break the siphonage

Removal of the contents of the distended stomach and intestine by an inlying duodenal tube operating as a simple siphon is of necessity bound to be ineffectual Siphonage is unsuited for the removal of fluid where gas is also present The entry of a column of gas into the siphon interrupts its action which can only occur spontaneously again when fluid accumulates in the stomach under sufficient pressure to force the gas out. Similarly, the application of suction to the longer tube will again restore its activity

The Degree of Suction Necessary

Although the alimentary canal establishes communication with the body surface at both its origin and termination it is essentially a closed system because of the various sphincters and particularly the cardiac sphincter of the esophagus and the ileocolic and external sphincters of the rectum Being a closed system it is apparent that the only reason it may be decompressed by suction is that the gastrointestinal tube is elastic Its walls may collapse when negative pressure is exerted upon its interior through this occurrence alone can the content of a distended stomach and intestine be evacuated by suction Were the walls of the gastro intestinal canal as unyielding as an empyema cavity in which thickening of the visceral pleura precluded expansion of the lung its content could not be removed by suction Despite employment of an enormous negative pressure in the instance of the empyema cavity first referred to unless the force were great enough to actually pull out the lung or cave in the chest wall, its entire content could not be evacuated by suction

Still in the very elasticity of the intestinal tube resides one of the hindrances to the employment of great negative pressures viz the engagement of the mucosa of the stomach and bowel in the perforations of the duodenal tube This may be overcome in part by the use of multiple perforations in the tube but is best regulated by the use of continuous mild suction From clinical trial and experimental test on the stomach and intestine of the dog and cat, 75 centimeters of water (2½ feet) would appear to be within the optimal range of negative pressure

Inasmuch as the intestine from the standpoint of the employment of suction is a closed tube a simple water siphon which is regulated easily constitutes probably the best of the available varieties of suction Intermittent suction with a hand syringe is not very satisfactory

The Hydrodynamics of Negative Pressure Applied to Rigid and Elastic Tubes

Paine (1936) has given special study to the mechanics of achieving decompression It has been indicated previously that when the intestine of the dog is filled with either water or air, it may be emptied readily by suction applied at one end Similarly a series of rigid glass U tubes arranged in a continuous circuit of vertical columns if filled with water can



Fig 34—Radiographs and charted course of a patient in whom decompression by suction was effected after fifty five hours Mr A W aged 35 developed gas pains on the day on which he was to have been discharged from the hospital following appendectomy for acute suppurative appendicitis Distension had been present occasionally during his convalescence but was not of the grade demanding suction (a) X ray film of abdomen taken after the first spell of copious vomiting 14 hours after the onset of gas pains Enemas had been given and no gas is visible in the colon (b) Film taken 13 hours after the commencement of suction The stomach is empty but there has been no appreciable reduction in the degree of distension of the obstructed bowel (c) After 44 hours of suction The existing distension has been con

be emptied if suction is applied at one end, granted that the other is open If the other end is closed, however, very little fluid can be removed no matter what suction is applied It has been indicated also that even in a closed system, the gut, when distended with either air or fluid may be emptied readily because of the elasticity of its wall

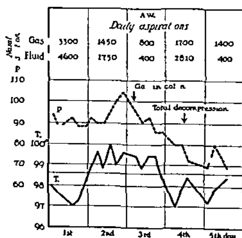
The effectiveness of negative pressure in the presence of interspersed segments of air and water is tested readily in both rigid and elastic tubes by direct experiment A series of three glass U tubes as mentioned above and arranged in a continuous circuit, provided with pet cocks, were filled with water in their lower halves while air occupied the upper halves of the tube Mercury manometers were attached at either end and suction was applied at one end, A, while the other end B, was open Twelve centimeters of negative mercury pressure was applied at A The pressure registered at B was 3 7 centimeters negative pressure The difference or 8 3 centimeters of mercury pressure had been taken up in the system and was represented by the difference in heights of the columns of fluid

A similar loss of effectual pressure in the elastic tube of the intestine is readily shown in attempting to remove by suction interspersed air and water injected into the gut of the dog or cat Considerable experimentation was done upon this phase of the problem in order to evaluate the technical difficulties concerned

The findings were quite uniform and the following experiment typifies the usual result Fifty cubic centimeter quantities of air and water were injected alternately at various levels in the small intestine of the dog The terminal ileum was tied and a duodenal tube introduced through the stomach was pushed into the duodenum Water manometers were attached to cannulas placed in the distended gut at four evenly spaced sites between the duodenal tube and the obstruction A uniform pressure of 38 centimeters of water was established by the intra enteric injections of 800 cubic

Fig 34 (*Continued*)

siderably reduced but no large amount of gas progressed into the colon Enterostomy was seriously considered at this juncture (d) After 50 hours suction there is now considerable gas in the cecum indicating that the intestine has re-established its continuity (e) Graph of the pulse and temperature record together with the quantities of gas and fluid aspirated during the period of suction The patient has been well without recurrence of symptoms of obstruction for 8 years



E

centimeters of air and water When 75 centimeters of water suction was applied, 225 cubic centimeters of gas and fluid were aspirated immediately and the pressure in the proximal cannula fell to 10 centimeters The pressures registered in the next, in sequence were 12, 15, and 14 centimeters of water respectively Despite continuance of suction for 10 minutes or increase of the degree of negative pressure applied, no more fluid or gas was evacuated It is observed, therefore that interspersion of gas and fluid interrupts effectually the ability of continued suction to evacuate the bowel Alteration in the position of the various coils rearranged the gaseous and fluid collections and permitted again the aspiration of a small quantity of gas and fluid

The reductions in pressure observed in clinical cases of obstruction attending the use of suction probably occur in the same proportion as was obtained in these animals, *the only difference being that the initial pressures* in small bowel obstruction are likely to be in the vicinity of 10 centimeters of water Were the gut a closed rigid tube containing fluid alone, which is incompressible, the removal of a few cubic centimeters might cause an enormous pressure to drop to zero The gut, an elastic tube, on the contrary contains compressible gas and incompressible fluid, and just to what extent an existing intra enteric pressure will be influenced by the aspiration of a portion of the content cannot be predicted in any given instance

The usual quantity of these aspirations is indicated in the graphs accompanying the pulse and temperature reactions No water was permitted these patients by mouth, so that the fluid readings are accurate In the instance of the gas aspirated corrections will have to be made for pres ure and temperature The gas in the bottle when the readings are made is under a negative pressure of 75 centimeters of water and consequently expands Within the gut the gas is at body temperature and so is greater in volume than when measured at room temperature These two factors practically offset one another, however

Measures Which Aid Decompression Where It Does Not Quickly Occur

When suction is long continued, the churning action of an active turbulent bowel and the absorption of some fluid from the gut which occurs with the elapse of time, and changes in posture and manipulation of the abdominal wall help to disarrange the existing interspersed collections of fluid and gas and so facilitate decompression If the small intestine were a large reservoir as the stomach or even a single uncoiled tube the decompression of interspersed segments of gas and fluid would be accomplished easily It would appear that the absorption of fluid from the gut might be facilitated through intravenous injections of concentrated solutions of acacia (30 per cent) by increasing the osmotic pressure of the blood Trials with such a method proved ineffectual, for though the osmotic pressure of the blood could be definitely influenced by this means, no appreciable increase of fluid absorption from the gut occurred

Use of the Miller Abbott tube, a double lumen and balloon tipped tube,

to facilitate decompression of the distended bowel will be discussed below in a separate caption

B INDICATIONS FOR THE EMPLOYMENT OF DECOMPRESSION BY SUCTION

The decision as to what agency is to be selected in securing relief of the obstruction is obvious when the obstruction is strangulating in nature or an obstruction of the colon with great distension is present In either instance, early operation is *urgently* indicated When, however, the obstruction is simple in character and concerns the small intestine the determination of the best remedial measure may be no easy task In the main it may be said that a trial with suction applied to an inlying duodenal tube is permissible in those cases in which clear indication for immediate operation does not exist If the distension be not great and the obstruction is incomplete, it is likely that decompression may be achieved by these means without operation Adhesive obstructions are especially amenable to treatment by conservative decompression in that partial evacuation of the bowel will frequently permit of automatic re establishment of intestinal continuity It is apparent that the removal of a quantity of gas and fluid near the site of obstruction will bring about such an adjustment more readily than removal of the same amount from the upper reaches of the intestinal canal In defense of suction applied to an inlying duodenal tube however it may be said that such drainage on the whole is usually considerably more liberal than from a catheter after enterostomy

Mechanical Obstructions Experience with the automatic establishment of intestinal continuity of the obstructed gut after decompression by enterostomy suggests that obstructions due to adhesions in which no strangulating mechanism obtains should be ideally suited to its use Trial with the method bears out this inference and indicates that almost invariably incomplete simple adhesive obstructions whether of remote or recent origin may be satisfactorily dealt with by suction applied to an inlying duodenal tube Not infrequently complete adhesive obstructions have to be decompressed by enterostomy after a preliminary trial with suction applied to a duodenal tube indicates that the obstructive mechanism does not relent The obstructive element observed in inflammatory lesions and particularly when masses are present constitutes a frequent indication for which the method usually adequately suffices Suction may be employed with advantage in a large number of obstructions of the small intestine in which the strangulating element is absent In fairly complete obstructions, however in which the probable nature of the obstructing agent is such that spontaneous re establishment of intestinal continuity will not follow decompression suction should not be persisted in long In such instance when whatever improvement attends decompression of the upper reaches of the intestine has been attained, recourse should be had to operation

The writer has always been timid over prolonged conservative management of instances of simple mechanical obstruction of the small intestine when no operative scars are present on the abdomen True enough, an

adhesive obstruction may be present in the absence of such scars and similarly a previous operative scar affords no absolute assurance that adhesive bands are responsible for the obstruction Nevertheless, the possibility of procrastinating in instances of an enteric intussusception or obstruction due to a gallstone in the bowel is considerably lessened if this guide is kept in mind These are essentially the two varieties of simple obstruction which can not be identified readily and which may be confused with simple obstruction caused by an adhesive band Congenital atresia of the intestine of the newborn is usually easily identified, as is ordinarily a stricture of the small intestine whether due to a neoplasm or a benign process

An obstructive agency which appears to relent, occasioning the patient to feel better temporarily and then renews itself again with repetitions of this sequence, is very likely to be due to an incarcerated gallstone In part, the temporary relief is due to the dilatation of the gut about the stone, in part, to onward descent with renewed impaction The writer has diagnosed bowel obstruction due to an impacted gallstone correctly on the basis of this sequence of events in the absence of a previous history of gallbladder disease or of events which would suggest the presence of an internal biliary fistula Whenever the slightest suspicion exists that a type of obstruction is present which will demand operative relief, as soon as whatever pre operative treatment appears indicated has been carried out, operation should be done

It can not be too vigorously emphasized that he who elects to treat a patient with mechanical obstruction conservatively must follow the decompression by subsequent x ray films Whereas this precaution is not so important in physiological obstructions, the writer believes that the clinical criteria of relief from pain and seeming improvement are not sufficiently accurate indices of whether the obstruction is relenting It is scarcely necessary to add that he has constantly practised what he believes and here advocates

As a guiding rule, it may be stated that, if progressive decompression is not manifest within twenty four to thirty six hours after the commencement of effectual suction, operation is in order This delay will permit of two to three check-up bed side films being made in the interval Increase of intestinal distension demands operation On occasions and especially during earlier years the writer has continued suction for a longer period than this and noted no special ill effects from this delay A safer rule, however, is to operate when a reasonable trial with suction has proved it ineffectual Even in those obstructions in which it is immediately apparent that operation is the only agency which will afford satisfactory and adequate relief the simultaneous employment of suction is desirable, not alone because it affords a means of evacuating the stomach and upper reaches of the small intestine but also in that incidental to operation and entry into the peritoneal cavity there is superimposed a temporary paresis of the gut, which added burden suction effectually combats Strangulating obstructions and acute occlusions of the colon with considerable distension will brook no delay with conservative measures of treatment Patients

with such obstructions should be submitted to immediate operation, when their general physical status permits

Functional Obstructions In the functional obstructions of nervous imbalance, whether due to inhibitive (paralytic) or spastic ileus, decompression by suction applied to inlying duodenal and rectal tubes is usually attended with success Occasionally, however and particularly when dealing with peritonitis, suction appears to affect the existing distension but slightly In such instances on the whole as indicated by the lack of distension attending early employment of suction in postoperative cases even in which distension would ordinarily occur, prophylaxis against further distension appears to be more readily attained than ablation of the existing distension Nevertheless the success of suction in controlling distension in peritonitis has shown that these patients may die from their peritoneal infection The impression held in many quarters that patients with peritonitis die largely because of intestinal distension has been set aside adequately by a large number of instances in which suction did away satisfactorily with the distension but the patients succumbed still to their peritoneal infection

In a number of cases of inhibitive (paralytic) ileus, the judicious employment of smooth muscle stimulants serves as a useful auxiliary to duodenal and rectal suction in the relief of distension The bowel wall is not paralyzed as the term "paralytic ileus" would imply The contractile activity of the bowel is inhibited by an overactive nervous system As Hotz (1909) showed experimentally the distended gut of peritonitis will contract when stimulated by a balloon placed within its lumen Spinal and splanchnic anesthesia will compel frequently an expulsion of gas and feces in the distension of peritonitis as described by Ochsner and his associates (1930), and others On the whole, however it should rarely be necessary to have recourse to these somewhat drastic expedients Hypertonic saline solution, as advocated by Hotz (1909) and Hughson and Scarff (1924) as well as eserin prostigmine and pituitary extract are usually effectual Even these agents are to be employed with caution in peritonitis because of the danger of disseminating the infection Nevertheless their use is fraught with considerably less risk than operation which seldom does much good but frequently does succeed in spreading the infection

Other Conditions in which the Employment of Suction Is Indicated

Whenever abdominal distension exists from whatever cause suction applied to an inlying duodenal tube is a valuable instrument in combating it The physiological obstructions whether they accompany operation infection injury or a miscellaneous group of condition are usually most effectually dealt with by suction exerted on an indwelling duodenal tube This agency is gradually supplanting the employment of enemas as a more effective remedial measure in the treatment of distension It has been pointed out already that the use of enema in the presence of intraperitoneal suppuration is hazardous The distension accompanying uremia pneumonia diabetic coma and fracture, whether of the spinal

column with associated injury of the spinal cord, or pelvis, ribs, or femurs, is best dealt with by suction Retroperitoneal hemorrhage or infection and thoracoplasty are among conditions which may give rise to considerable distension Inhibition of intestinal activity in some degree attends every intraperitoneal invasion, whether it be by the surgeon, infection, hemorrhage, or leakage from the alimentary canal With reference to the employment of suction after operation, it is to be remembered that, suction is more effectual in the prophylaxis of distension than it is in contending with such physiological obstructions *after the establishment of distension* In operations upon the stomach, biliary tract, or spleen, in which the occurrence of distension is to be anticipated, routine employment of suction *will insure almost invariably a convalescence free from this complication* It is also of value in diminishing the tension upon an intestinal suture line The application of suction to an indwelling duodenal tube is a worthwhile procedure in the performance of colostomy in that it permits of greater delay in opening the bowel With frequent use of suction applied to an inlying duodenal tube, the dreaded acute dilatation of the stomach after operation has ceased to exist

Suction serves an extremely important purpose in combating distension attending the occasional complication of evisceration through vertical incisions With the aid of a small dose of an appropriate intravenous anesthetic (pentothal sodium), the intestines are returned to the abdomen, *a piece of rubber dam (Penrose drain) is led through the wound and* liberal adhesive strapping is applied The drain carries away the secretion and the adhesive strapping remains firm for the requisite period of time, *usually about two weeks No sutures are placed The employment of* suction deals satisfactorily with the obstructive element, in the main, as firm abdominal walls are obtained as with secondary closure and more lives are saved Since vertical abdominal incisions in this clinic have *been* closed with interrupted sutures of fine buried silk, evisceration has become an extremely rare occurrence Substitution of oblique or transverse, for vertical incisions, and closure with interrupted sutures of fine silk has practically eliminated evisceration as a complication of elective abdominal surgery in this clinic

In combating the night pain of patients hospitalized for the treatment of uncomplicated gastric or duodenal ulcer, suction has been found effectual The removal of gastric juice secreted when food is not taken during sleep obviates the occurrence of these pains Suction is useful also in keeping the stomach empty in the presence of gastric hemorrhage from an ulcer If a large intragastric hematoma is allowed to accumulate, perforation of the thinned out ulcerated area is more likely to occur—a complication which has twice come to the writer's attention in cases treated "medically" in which water by mouth had been withheld The employment of suction apparently does not increase the bleeding, the duodenal tube should be irrigated frequently enough to permit of aspirating the blood However, suction is not to be considered a substitute for surgical intervention to arrest hemorrhage, in the presence of active massive hemorrhage from a bleeding duodenal ulcer

Contraindications to Suction

There are essentially two absolute contraindications to the employment of suction as the sole active remedial agent in dealing with bowel obstruction, viz (1) strangulating ob tructions with compromise of the blood supply, and (2) acute obstruction of the colon with enormous distension of the proximal colon The latter being converted into a closed loop type of obstruction, by the proximal competent ileocolic valve and sphincter is as previously related, essentially a strangulating obstruction In all such instances, decompression of the distended colon by operation is in order In partial obstructions of the colon with les er grades of distension suction applied to an indwelling duodenal tube in obviating further distension from the upper reaches of the intestine, frequently permits of dealing with the lesion in the gut in a non obstructive phase

It is probably not amiss at this juncture to say something concerning the alleged more serious character of high obstructions as contrasted with the low Though this impression should have been corrected adequately with the knowledge that the loss of electrolytes and essential fluids constitutes the special hazard in high obstructions, this opinion is still encountered amongst clinicians Saline solution counteracts the evil effects of these losses The easier evacuation of the upper reaches of the intestine by vomiting precludes the development of distension and the high intraenteric pressures observed in lower obstructions Probably the most vicious type of obstruction ob erved clinically is that which occurs acutely in the pelvic colon There is frequently no vomiting and no loss of fluid The only finding may be an enormous distension As has been described, this is essentially a closed loop obstruction with a high intra enteric pressure Unless relieved the colon may perforate The dictum that the high obstructions are the most perilous should be amended to read that low obstructions on the contrary, are more dangerous because of their effects on the bowel wall

C TECHNIQUE OF THE EMPLOYMENT OF SUCTION

The sphincters of the stomach and esophagus make of the upper portion of the gastrointestinal tube a closed system In consequence a simple water siphon as shown in the accompanying diagram (Figs 35, 36), constitutes a satisfactory source for effectual suction It is to be noted that the catheter employed (Fig 37) has holes cut back over a distance of 23 centimeters The entrance of the distal end of the catheter into the duodenum is to be desired, in order that simultaneous suction may be exerted on both the stomach and duodenum In event that the catheter remains in the esopha gus and does not enter the stomach or is regurgitated back into the esophagus suction will be ineffectual As is indicated below routine practice in this clinic in the management of mechanical obstruction is to employ the Miller-Abbott tube for once this tube has entered the duodenum, its migration into lower reaches of the intestinal canal, facilitates and ensures earlier decompression

Passing the Catheter

The duodenal tube with the urethral tip (Levin duodenal tube) can be inserted usually without causing the patient any distress Before the lubricated tip of the catheter is introduced into one of the nares, the patient is asked to take a sip of water through a drinking tube This water is held in

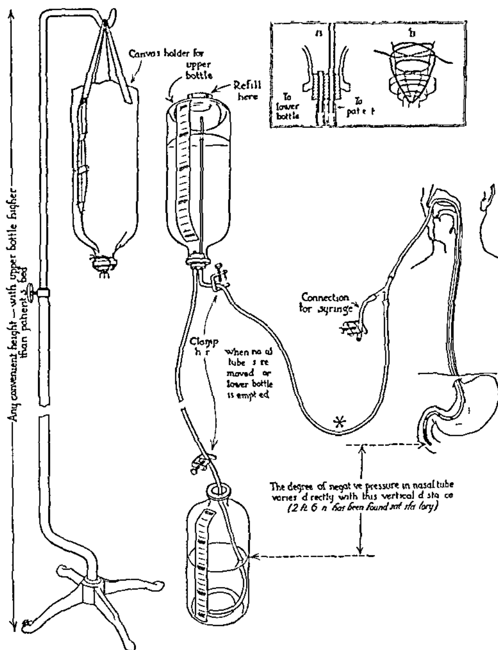


FIG 35—Suction apparatus for gastro-duodenal siphonage A trap bottle is always used when the fluid returns are large (Transactions Western Surgical Association 1931 and West J Surg 40 1 1932)

the mouth and is only swallowed as the tip of the tube is advanced through the nasopharynx and is felt by the patient in the throat, at this juncture he takes more water through the drinking tube and swallows it as the tube is introduced This manner of inserting the catheter permits almost invariably of its accomplishment without discomfort to the patient Preliminary spraying of the oral pharynx with cocaine has had to be resorted to on very rare occasions Infants may be gavaged usually without difficulty In order to facilitate entry of the tube into the duodenum a catheter with a leaded-tip has been made up (Figure 37) As soon as the tube has entered the stomach, the clamp on the water siphon is removed and the contents of the stomach are evacuated by suction. When the stomach is empty as determined by the return of clear water on further swallowing the action of the suction is interrupted by clamping the rubber tube leading to either bottle the patient is turned on his right side and the catheter is advanced two to three centimeters every five minutes The end of the catheter being heavy and the stomach empty it is hoped that this maneuver will bring the catheter into the vicinity of the pylorus The patient is now permitted to drink about half a tumbler of water As the water leaves the stomach entry of the catheter into the duodenum is favored. In this manner the duodenum can be intubated with fair regularity After half an hour when the duodenal tube has been advanced fifteen to twenty centimeters more the tip should be well into the duodenum Unless distension is very great, this maneuver in the main proves quite successful Inhalation by the patient of an ampoule of amyl nitrite broken into a handkerchief aids relaxation of the pyloric sphincter The catheter should not be attached to the cheek and upper lip with adhesive tape until the catheter has been advanced well into the duodenum It is advisable at this juncture to secure evidence by fluoroscopy or an x ray film as to where the tip of the catheter is Granted that it is in the duodenum efforts should be made to advance it well into the small bowel. If the initial tube is not long enough another may be fastened on at the

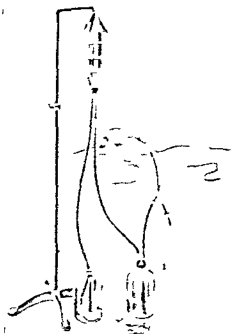


FIG. 36—Three bottle suction apparatus The Pottenger rubber connections are employed to cap the suction bottles The force of suction when a trap bottle is employed is determined by the distance between bottles 2 and 3 (See Fig 35)

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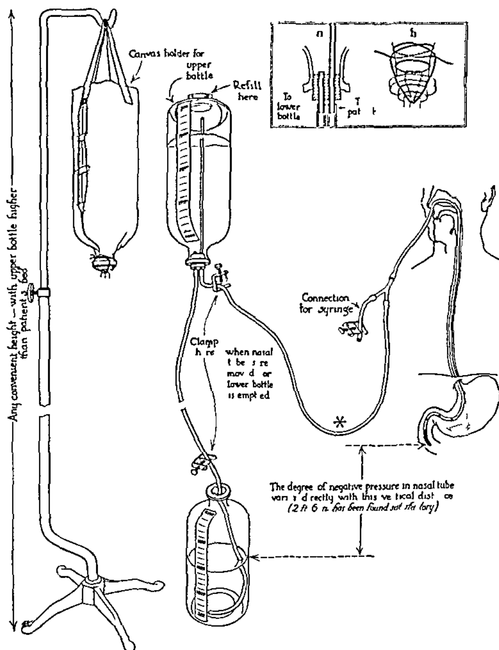


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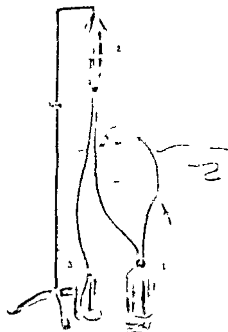


FIG 36—Three bottle suction apparatus The Pottenger rubber connections are employed to cap the suction bottles The force of suction when a trap bottle is employed is determined by the distance between bottles 2 and 3 (See Fig 35)

oral end In mechanical obstruction of the small intestine, regurgitation from the intestinal canal into the stomach occurs with regularity In consequence, the color and reaction of the returned fluid is not as accurate an indication of the position of the tube as is this same criterion in unobstructed patients The first x-ray film taken some hours after the commencement of *suction will give reliable evidence on this point* Attempts have been made with this tube with the heavy leaded tip to intubate the duodenum with the aid of the fluoroscope as an initial step On the whole, however not enough is gained to make it worth the effort as a routine procedure If, however, duodenal intubation can not be achieved in the manner described, a trial with fluoroscopic control is in order In physiological obstructions, entry of the tube into the duodenum does not appear to be so important for successful decompression Because of the multiple *perforations extending over a considerable length of the tube, it is apparent* that as the catheter begins to exhibit signs of wear, that it becomes unsuitable for employment in instances of mechanical obstruction, the tendency of the tube to bend at one of the perforations proximal to the leaded tip causes the course of the tube in the stomach to be deflected away from the gastric pathway of the lesser curvature

Additional Schemes to Intubate the Duodenum

Development of measures more certain to succeed in the intubation of the duodenum, are very much to be desired Hay (1941), of this clinic, has worked with a flexible adjustable cylindrical tube which is passed into the stomach The tip of the instrument may be pulled into the vicinity *of the* pylorus, under fluoroscopic control This object being achieved, a duodenal tube may then be passed through the cylindrical tube into the pyloric canal If this scheme proves practical it should be a great boon to intubation of the duodenum and to use of the Miller-Abbott tube

Paine (1933) suggested, without trying some years ago the use of a magnet to facilitate entry of a tube into the duodenum On a visit to the Kirschner surgical clinic in Tubingen in 1928 Willy Usadel pointed out *to the writer, a large discarded electromagnet which Payr had* employed with the intent of severing (or pulling apart) intestinal adhesions bloodlessly without recourse to operation Kirschner had implanted steel balls beneath the skin, the alleged purpose being to elevate skin flaps, *with the* use of the electromagnet According to Usadel, experiment showed both these dreams to be bubbles These considerations suggested to the writer that Paine's idea of intubating the duodenum by employing an electro magnet had little merit to recommend it Gius (1941) has the impression, from preliminary trials, that a duodenal tube mounted with a suitable bucket possessing magnetic properties, may be directed into the duodenum, despite the insulating qualities of the abdominal wall

Doss (1938) attached small lead shot, attached by a short thread 6 to 10 inches in length, as a leader to the tip of the duodenal tube—the thought being that the lead shot would enter the duodenum and pull the duodenal tube after it Smith *(1941) has worked with the same scheme also* As a matter of fact, the lead shot entered the duodenum quite readily Subse

quent manipulation of the tube succeeds, however, only in pulling the lead shot back into the stomach Some variant of this scheme may result also in facilitating entry of the tube into the duodenum (See caption on the Miller Abbott tube and its use below)

The Apparatus

The materials necessary for the construction of a water siphon which will supply an active source of suction suitable for use in aspirating gas and fluid from the stomach and intestine are readily available in any hospital and an intern can assemble the apparatus easily Two large bottles which can be graduated and so connected with rubber tubing that water can run from the lower position of the upper to the lower bottle constitute such a source for active suction When the upper bottle and the rubber tube leading down to the lower bottle are filled with water and the distal end of this tube is submerged beneath a short column of water in the lower bottle the apparatus is ready for action The tube which leads from the duodenal catheter to the upper bottle should have a Y connection so that one may readily perceive by opening this side arm whether the suction apparatus is working properly It affords also a means of irrigating the duodenal tube which is very likely to become plugged with mucus or other aspirated content if this precaution is not observed When the return from the stomach contains thick tenacious shreds frequent irrigation of the tube is necessary to keep it open A warm solution of soda affords a good solvent for mucus If a patient with obstruction continues to have nausea or vomiting the tube is either plugged or it is not in a satisfactory position If the tube can be irrigated freely but there is no return of fluid with the suction open the lower end of the tube is probably in the esophagus A critical and minute attention to these particulars is very important

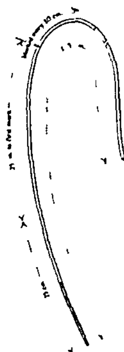


Fig 37—Duodenal tube with multiple perforations and lead ed tip employed at the University of Minnesota Hospital for the relief of distension

In instances in which the amount of fluid aspirated is great, it is always well to insert a trap bottle in which the fluid aspirated from the stomach may be collected directly Especially is this important when the suction is prolonged over a considerable period of time A portion of this collected fluid may then be returned again by proctoclysis Of the fluids removed by aspiration the gastric and pancreatic juices are undoubtedly the most important Total loss of gastric juice is incompatible with life (Walters Kilgore and Bollmann) so similarly with pancreatic juice (Elman and McCaughan) Bile, though important for normal health, is not absolutely

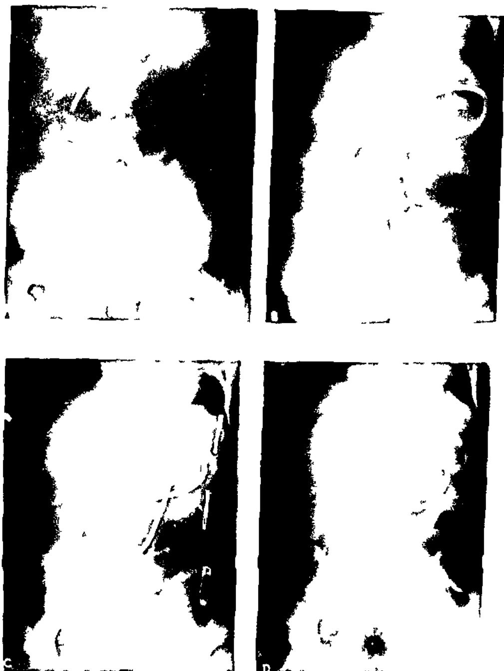


FIG 38—Enterostomy employed to complement duodenal siphonage because of the appearance of symptoms suggesting strangulation Mrs A G aged 44 had a hysterectomy performed 8 years ago Admitted with a 72 hour history of obstruction (a) Film showing grade and extent of distension a few hours after institution of suction The leaded tip of the tube is entering the duodenum (b) Considerable reduction in distension after 72 hours suction there is no gas in the colon however and slight rebound tenderness is present suggesting the necessity for operative intervention (c) Radiograph made directly following enterostomy a slight amount of clear fluid was present in the peritoneal cavity (d) Twenty four hours after enteros

necessary for the maintenance of life (Whipple). The liberal administration of saline solution will supplant adequately, at least temporarily, the loss of gastric juice through a complete gastric fistula. Animals can not be kept alive indefinitely by any known means when all the pancreatic juice escapes through a fistula. If, however, a dog with such a preparation is allowed to lick the fistulous opening and thus reingest some of the pancreatic ferment, he may survive such loss. Whenever the fluid returns by siphonage are great, it is very important therefore to catch the fluid in a separate trap bottle and return a portion of it through an enterostomy catheter or by proctoclysis. When such a third bottle is inserted, about 200

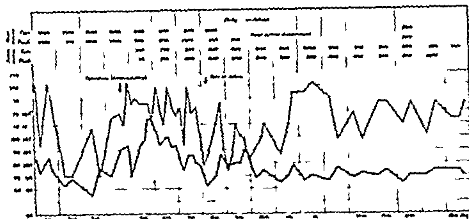


Fig. 38.

cubic centimeters of air, trial has demonstrated, must be removed by siphonage before the suction becomes apparent on the duodenal tube. When the water in the top bottle has run out, it may be filled by taking it off the sling and refilling it or through the special hole made at the top for the purpose (Fig. 35). Singleton of Galveston has suggested insertion of a Y directly between the tube leading to the top bottle and the tube leading away from it. This permits of collection of the aspirated fluid in the bottom bottle and the accumulation of gas in the upper bottle. Pratt suspends the bottles on a portable stand with a large T arm in such a manner that either tube might be easily elevated or lowered. The gas escapes through a special valve and can not therefore be measured. In more recent years a number of other modifications in assembly of the apparatus have been suggested. Because of the simplicity and ready availability of the apparatus described above, it appears to meet adequately all the conditions of convenience. The total cost of the materials in the siphon apparatus employed at the University Hospital is about a dollar.

Whenever indication exists for the employment of suction, the volume of

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tomy, gas is present in the colon. The patient has remained well. (e) The graph indicates the pulse and temperature reaction attending the employment of suction and the performance of operation. The lesser drainage following enterostomy indicates that the bowel has released itself from the obstructing agent.

fluid and gas removed should be determined *Especially* is this important when the fluid return is great Whatever fluid is aspirated must be subtracted from the *fluid intake* The aspirated fluid then serves not only as a measure of the grade of obstruction present but also as an important factor in determining how much fluid should be administered At the University Hospital (Minneapolis) it has been routine practice to employ 4 liter bottles Suction is arbitrarily commenced for purposes of uniformity *with 400 cubic centimeters in the bottom bottle* Gradations in amounts of 200 cubic centimeters are marked in ink on a strip of adhesive tape and fastened on the bottles For every centimeter of gas or fluid aspirated, a centimeter of water is displaced into the lower bottle The gas aspirated remains in the top bottle, if the return was wholly fluid, there would be no change in the level of the water column in the top bottle, for every centimeter of water displaced another centimeter of aspirated fluid would take its place *Hence, the amount of gas aspirated may be read directly, from* the net sum of fluid displacement into the lower bottle, the gas reading is subtracted, this remainder indicates the fluid aspirated These computations should be made every 24 hours (6 00 A M) and charted by the nurse as indicated in Figure 72 These directions concern computations of fluid and gas aspirations in a two bottle suction apparatus (Fig 35) In a three-bottle apparatus which is being used more and more, the aspirated *fluid collects in the trap bottle (Fig 36) and the gas collects in the upper* bottle

Einhorn (1940) stated recently that the type of black tipped leaded tube illustrated here (Figures 35, 36, and 37) with multiple perforation is ineffectual in emptying the stomach Einhorn, it appears, failed to weigh the difference in behavior between rigid bottles with open necks and a contractile stomach and duodenum with physiologically active sphincters in the esophagus Einhorn's statement is disaffirmed further by the success attending use of this type of tube in effecting decompression of the upper gastro intestinal canal, in a number of hands When some of the perforations lie above the fluid level, air will be sucked out of the stomach before fluid is removed Schwyzer (1939) and Smith (1941) have confirmed the *verity of this contention by experimental trials on a contractile* stomach, distended with air and fluid

How Long Is Suction to Be Continued?

In mechanical obstruction, inspection of x ray films made at the bed side at 12 to 24 hour intervals, after the commencement of *suction, and* the amounts of gas and fluid returned by aspiration furnish good evidence *as to the progress* of the decompression and determine also whether operation is necessary Before removing the duodenal tube, it is always a good plan to interrupt the suction for intervals of increased lengths of time When clear fluids can be taken and no distress is occasioned *after suction* has been discontinued a few times over a period of three or four hours, it is *safe to remove the tube*

In the use of suction to obviate the occurrence of gaseous distension after operation, the same indication is to be observed for the discontinu

ance of siphonage Patients learn to release the clamp on the tube themselves not infrequently when interruption of suction causes them distress Occasionally, it is necessary in peritonitis to leave the duodenal tube in for several weeks, alternating suction and oral intake of clear fluids before the normal motility and transport power of the bowel have become fully re established

In the relief of distension by the employment of suction the question suggests itself naturally as to how far a duodenal tube may be passed down into the bowel A number of years ago McClendon observed that a small tube could be made to enter the lower reaches of the ileum In a text of a later date (1925) a roentgen film indicating the position of the tube is shown McClendon found that a tube 7 feet (2 13 meters) in length reached from the teeth to the terminal ileum in an adult Van der Reis and Schembra have indicated also that the physiological length of the gut is considerably shorter than the anatomic lengths of which we are more accustomed to think Not uncommonly after the tube enters the duodenum after operation as well as in mechanical obstructions treated conservatively the distal end of the tube is observed to have made its way well into the jejunum The tube which the writer has employed most commonly (Figure 37) has perforations extending proximally from its distal tip for a distance of only 27 centimeters (10 6 inches) Inasmuch as it is important to exert suction simultaneously on both the stomach and the small bowel in instances in which it is deemed especially desirable to have the catheter enter the lower reaches of the jejunum or even the ileum the precaution is to be observed of employing a tube with perforations extending well proximally At first glance it might appear that suction employing a closed system would be ineffectual until all of the tube containing perforations had passed beyond the cardiac sphincter of the esophagus Such, however, is not ordinarily the case The superior sphincter in the cervical esophagus suffices to maintain the closed system intact Only rarely does a water siphon system "leak" when a portion of the perforated tube remains within the esophagus Van der Reis and Schembra have succeeded in passing tubes throughout the entire length of the intestinal canal Entry of the duodenal tube into the upper jejunal coils occurs not uncommonly in mechanical obstructions treated conservatively It would therefore appear that in certain types of mechanical obstruction in which the time element is of no great concern that the extent to which the principle of suction may be employed is limited only by the persistence and ingenuity of the surgeon and the endurance of the patient

The Miller-Abbott Tube and Its Use

In 1934 Miller and Abbott developed a double lumen, balloon tipped duodenal tube for intubation of the small intestine In 1938 Abbott and Johnston announced the passage of this tube well down into the lower reaches of the bowel, in patients with mechanical obstruction of the small intestine They observed that following intubation of the duodenum inflation of the small balloon at the tip, stimulated the gut to contract down upon it and propel the balloon and duodenal tube in a forward direction

down the bowel After the balloon tipped catheter (Fig 39) has entered the duodenum, it is amazing how quickly it may be propelled down the bowel sometimes In a few *instances, it has been impossible to get the tip* of the catheter beyond the duodeno jejunal angle, despite frequent change of posture by the patient, or deflating or increasing the inflation of the tube The more serious obstacle to achieving quick decompression with the Miller-Abbott tube, however, is difficulty which concerns the more frequent case, in which it takes a long time, and even days to get the tube out of the stomach In some of these patients, decompression is achieved by suction applied to the indwelling gastric tube, while passage of the tube out of the stomach is awaited Unfortunately, in the patients with the greatest distension, in which quick intubation of the duodenum is

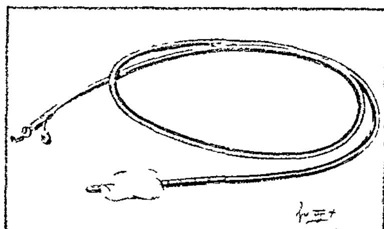


Fig 39—The Miller Abbott double lumen balloon tipped tube for intestinal intubation

most important, in these very patients, the greatest difficulty is had, almost invariably The greater the distension, apparently, the greater the difficulty in securing early migration of the tube out of the stomach The best scheme for duodenal intubation is essentially the same as with the ordinary duodenal tube the balloon being deflated, of course, until the duodenum has been entered There are a few cases in which the tube *moves down the bowel satisfactorily but in which subsequent x ray films* reveal persistently distended coils of small intestine, that can not be decompressed Such patients need an enterostomy to effect satisfactory relief from obstruction Occasionally retention will occur in the stomach, despite migration of the catheter well into the lower reaches of the obstructed intestine In such instances, an additional catheter may have to be placed in the stomach and left in place for a few hours each day

Despite many obvious shortcomings the long, balloon-tipped duodenal tube has been a great boon to extension of the advantages of conservative decompression to certain types of obstruction The indications and contraindications for its use, are essentially the same as for the ordinary duodenal tube The chief advantage in its use lies in the quicker decompression which



Fig 40—High grade obstruction relieved by Miller Abbott tube (a) Distension on entry to hospital The obstruction appears to be complete (b) Complete decompression achieved after 48 hours Another duodenal tube was inserted into stomach to allay vomiting The tube stayed in situ several days and the patient continued to eat without manifesting signs of obstruction However on withdrawal of the tube the patient reobstructed Suction was ineffectual and enterostomy had to be done Eventually partial enterectomy was done because of the complicated character of the obstructing mechanism The patient has remained well



Fig 41—Miller Abbott tube in decompressing obstructed bowel (a) Extent of distension The patient had been obstructed several hours on arrival (b) Partial decompression *achieved by the Miller Abbott tube still lying in duodenum—after* 120 hours (c) Complete decompression was not achieved until suction had been in force for more than 10 days An ordinary duodenal tube has been inserted into the stomach because of the occurrence of gastric distension and vomiting The wisdom of carrying on attempts at effecting decompression by conservative means so long is open to serious doubt

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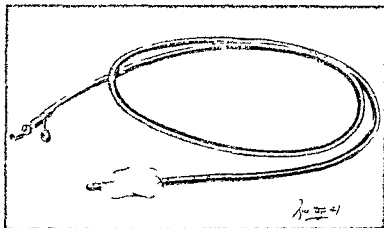


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advantage in Sivertsen's suggestion concerning the employment of mercury lies in the extremely mobile character of mercury Employing a funnel, one can pour mercury (1 to 2 cc) easily into the small tube leading to the balloon, and the greater portion of it can be expressed again from the balloon Should the balloon break in its transit through the intestinal canal no harm would ensue from the presence of this amount of

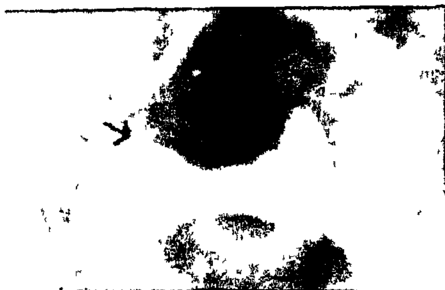


Fig 42—Use of the Miller Abbott tube in locating an occult intrinsic obstruction in the bowel The defect between the arrows was due to a carcinoma of the retroperitoneal duodenum It was excised successfully

mercury within the bowel It remains to be determined how practical this suggestion will be

Other Uses of the Miller Abbott Tube

In addition to the patient presenting acute intestinal obstruction, the Miller Abbott tube is of special value in preparing the patient for operation with recurrent obstruction For, with the tube well into the lower reaches of the small bowel, suction may be expressed there to allay distension, the patient being permitted to eat meanwhile Patients who have had repeated episodes of obstruction and a long period of starvation are notably poor risks for operation One such patient with a very fatty liver came under the writer's notice A protracted period of simultaneous feeding of a high protein and carbohydrate diet while suction was in force would have averted this error Johnston and his associates have pointed out the greater ease of maintaining fluid balance in patients having this type of suction, as contrasted with patients having the tube lying in the duodenum

Some surgeons notably Whipple (1940) employ the Miller Abbott tube regularly in resections of the colon feeling that the advantages of a complemental enterostomy are provided therewith In this clinic, it has

attends intubation of the lower reaches of the small intestine In this clinic, we have come to employ the Miller-Abbott tube regularly in all obstructions which appear suitable for relief by conservative decompression Yet, in the three-year period, during which the Miller Abbott tube has been used regularly, in this clinic, the incidence of successful decompression, without recourse to operation, has not been greater than it was with the use of the ordinary duodenal tube, previously Nevertheless, in all obstructions, in which the objective is to decompress the distended intestine, the Miller Abbott tube should be employed routinely During the past year, in this clinic, the tendency in the management of cases, with great distension, which respond slowly to conservative means of decompression has been to veer away from too protracted efforts at achieving decompression in this manner Timely and well executed surgery holds out less risk to such patients If efforts at conservative decompression are persisted in too long, the distended lower reaches of the bowel are damaged and the patient comes to operation a worse risk than if operation had been performed earlier The risks of decompression by conservative means mount only, if the method fails Successful decompression by the conservative method carries, as reports from this and other clinics (Abbott and Johnston (1938), Johnston and associates (1938) and Leigh, Nelson and Swenson (1940)) a very low risk How many patients die eventually from operation because suction was persisted in, too long is not determined readily Without question, it is an item that deserves consideration Suction has taught that decompression without spillage is synonymous with success The surgeon must learn also how to achieve decompression *without spillage* in those cases in which operation is mandatory

Latterly (October 1941), Abbott has described a method of intubating the duodenum with employment of the long, balloon tipped tube, which promises to enhance the usefulness of the conservative method of achieving decompression Abbott employs a piece of piano wire with a diameter of 4 mm Two feet proximal to the balloon, the side of the Miller-Abbott tube is perforated with the wire, which then follows the lumen of the tube, terminating just proximal to the suction holes in the catheter A small twist in the wire at the site of entry of the wire into the Miller Abbott tube prevents it from moving forward within the lumen of the tube Under the fluoroscope this stiffening of the proximal reaches of the Miller Abbott tube permits, not uncommonly, immediate entry of the duodenum by the tube In this clinic, this scheme suggested recently by Abbott has been employed with more satisfaction than other techniques described previously to facilitate entry of the duodenum by the Miller Abbott tube

It is interesting that twenty years and more ago, before development of the urethral tipped duodenal tube of Levin (1921), every duodenal tube came equipped with such a wire stylet to facilitate passing of the duodenal tube by mouth A discarded useful technique of the past has been resurrected and put to good use again

Sivertsen (1941) suggested to the writer that, placement of metallic mercury into the balloon of the Miller Abbott tube would facilitate entry of the tube into the duodenum Lead is used for this purpose in the black tipped tube The atomic weight of mercury is 200, that of lead 207 The

distension, (3) the visualization of gas in the colon on the x ray film in complete obstructions, indicating that the obstruction has been overcome, (4) less fluid aspirated through the duodenal tube, denoting that stasis is no longer prominent, and (5) toleration of temporary discontinuance of suction without recurrence of pain

With reference to cessation of pain following the institution of suction one caution is to be observed viz, that the bowel having accommodated itself to a certain grade of distension, no accretion occurring, in that the swallowed air and fluids discharged into the duodenum being removed by suction, which increments would otherwise augment the distension, the patient may not be conscious of any painful contractions In all mechanical obstructions treated by suction, therefore, it is highly important to have an x ray film every twelve or twenty four hours, depending on circumstances, to be certain that the caliber of the distended gut is actually becoming smaller

No narcotics need or should be given these patients Continued pain indicates that decompression is not adequate by the method It is a good plan however to apply heat to the abdomen It is routine practice in this clinic, to give 5 to 1 grain (30 to 60 mg) sodium luminal hypodermically three times a day (adult dose), while suction is in force to obtund the sensibility of the patient to the irritation in the throat, occasioned by the presence of the tube (See Section I below)

D SHORTCOMINGS OF SUCTION

Apart from the mechanical handicaps described previously, there are two inherent weaknesses in this method of treating mechanical obstruction with suction alone (1) Drainage of the gut is done at a point remote from the site of obstruction, necessitating the removal of a much greater quantity of gas and fluid to permit of the intestine automatically adjusting itself and re establishing its continuity than if the gut had been drained by enterostomy near the point of obstruction (2) In the interval during which one waits for the obstructing mechanism to relent, the gut above the obstruction cannot be employed as a nutritive tube as it can when the gut is drained near the point of obstruction The Miller Abbott tube however, circumvents this latter difficulty in that the patient may eat with the tube in place, after decompression has been effected

E THE RESULTS OF CONSERVATIVE DECOMPRESSION

The results of any method of treatment are best evaluated in its successes and failures The obstructions in which suction has its widest field of usefulness are the adhesive variety, where drainage of the bowel may permit automatic re establishment of intestinal continuity Suction has come to displace, almost completely, more aggressive means of dealing with physiological types of obstruction due to nervous imbalance A fairly large number of reports have accumulated now, attesting the great value of conservative decompression in the management of intestinal obstruction The mortality in the group treated by suction alone has been astonishingly small In this clinic, the case mortality in the suction group

been found that suction applied to an ordinary indwelling duodenal tube immediately before, during, and constantly after operation for a period of five days will preclude the occurrence of intestinal distension

Another use to which the Miller Abbott tube has been placed by the roentgenologist is the identification of tumors in the small intestine Because of the rapidity of transit of barium down the small intestine, the recognition of obstructions in the small intestine by ordinary roentgen means has been notably poor The value of the stasis ray may be pyramided by blocking off a section of the small bowel by inflating the Miller-Abbot tube Defects in the barium column within the bowel may then be identified more readily (Fig 42)

Complications Involving the Tube

Knotting may occur in any tube passed into the stomach This observation has been made, probably, in many clinics, in which an indwelling duodenal tube is used frequently The balloon of the Miller Abbott tube has been the source of some difficulty The injection of barium into the small channel of the double lumen tube leading to the balloon has been a source of trouble (Walker 1940) in some clinics A more serious potential source of trouble is employing too great a pressure within the balloon, causing it to become arrested in its migration down the bowel That protracted arrest of the balloon, in one place might injure the bowel is apparent Periodic deflation, however, should make this an infrequent complication Further, anyone employing the balloon-tipped tube, should orient himself well with reference to the status of inflation of the balloon at various grades of distension The size of the balloon employed has much to do with the amount of air to be injected into it Ordinarily, a small balloon which measures 4 to 5 centimeters in length when inflated and 3 to 3 5 centimeters in width when distended with 20 to 35 centimeters of air, gives about the right amount of contractile stimulus to the bowel wall

In attempting to intubate the cecum in a patient in this clinic exhibiting moderate distension, the balloon became arrested, apparently at the ileocecal juncture (Smith) The balloon assumed an hourglass shape (thorotrast contrast medium employed), and that portion engaged beyond the ileocecal sphincter could not be deflated Finally, it ruptured spontaneously, permitting withdrawal of the catheter An erroneous diagnosis of stricture of the terminal ileum was made on the basis of the roentgen findings Exploratory operation revealed no lesion present there, suggesting arrest of the balloon in the ileocecal sphincter as a likely explanation

Any tube which remains long in the intestine is likely to become discolored (black) Washing the tubes frequently with warm soapy water, employing both forced injection and suction, keeps the tubes clean and the channels open and, serves also as a satisfactory deodorant

The "Ear-Marks" of Successful Decompression

In a mechanical obstruction of the small intestine the signs of a successful decompression are (1) cessation of "gas pains," (2) decrease of

These observations are not interpreted as an indication that it is wise or desirable to pursue efforts at conservative decompression in complete adhesive obstructions in which the obstructive agent does not relent. They do indicate, however, that as long as the gut is viable, even though decompression is not achieved, that the patient's general condition remains quite the same in so far as one is permitted to judge from the pulse, temperature, and general body functions. The continued well being of these patients with severe obstruction on which suction was employed for several days before resort was had to operation has a significant bearing upon the so called toxic factor in obstruction. The bowel wall being viable despite the presence of considerable distension, no evidence of abnormal absorption occurred. This feature corroborates in a decisive manner the conclusion reached in the experimental observations, viz., that it is probably transperitoneal absorption through a bowel whose viability is impaired which determines the supervention of toxic symptoms. If abnormal absorption by the normal avenues were occurring in these patients no objective manifestation of its happening came to light.

The experiments made upon the hydrodynamics of suction applied to rigid tubes as well as the effects of suction noted in the terminal ileum upon the intra enteric pressure of obstructed dogs and cats indicate that release of pressure at a site nearer the obstruction is in order when suction fails to influence the existing distension favorably. The observations cited above should not be construed to suggest therefore that trial with suction may be continued indefinitely. Experience dictates that in late simple obstructions, enterostomy is safer and wiser usually than release of the obstructing agent.

The Role of Conservative Decompression in the Prevention of Intestinal Obstruction

The employment of suction in the early postoperative period, after abdominal operations, eliminates almost entirely the occurrence of distension. Obstructions in the convalescent period are brought about largely by the collection of fluid and gas in a bowel whose motility is impaired. Whereas when empty such a gut may not be obstructed readily by a few fibrinous adhesions, when heavy because of lack of absorption of the large quantity of fluids normally emptied into it, a few fibrinous adhesions may block its continuity readily. Though no figures are available to substantiate this opinion, nevertheless it is difficult to escape the impression that, the avoidance of distension in convalescence after abdominal operations will and has lessened materially the tendency to postoperative mechanical obstruction during the hospital stay. Whereas postoperative obstruction demanding operative release was not a rare event prior to the routine employment of suction to prevent distension in instances where one would anticipate its occurrence, the practice of applying suction to an inlying duodenal tube appears to have done away largely with this complication. There is no reason apparent to expect, however, that the incidence of remote obstructions will be affected in any manner

has been only 6 per cent It is not to be denied, however, that there is a factor of mortality, not so readily assessed, yet, nevertheless *directly* attributable to overextending the indications for suction It is to be admitted freely that suction is far more dim sighted than "blind enterostomy" in certain cases It is highly important, therefore, that he who employs conservative decompression in the management of intestinal obstruction, school *himself, not alone, in the advantages, shortcomings* and weaknesses of the method, but also in the intricacies and limitations of diagnosis of acute abdominal disorders The application of suction, as the sole direct therapeutic agent to unsuitable cases, such as strangulating obstructions, is a tragic blunder which must be avoided studiously The results of conservative decompression will be dealt with subsequently again under the caption of The Mortality of Obstruction (See Table XXV) In most other mechanical obstructions, it *is largely an auxiliary aid*

The After Story of Patients with Bowel Obstruction Treated Conservatively

The majority of the patients who have been treated by conservative decompression for obstruction have been examined or interrogated A number have been subjected to enterolysis or to partial enterectomy because of recurrent obstruction, entangling adhesions being found usually at operation A much larger number have remained well This information is *not startling and is in accord with the experience of enterostomy for obstruction*, viz, that an adhesive band may be presumably present for years attached to the bowel without interrupting its continuity When stasis occurs in the bowel for some reason and the small bowel becomes full of fluid, the band may kink and obstruct the gut

Lessons Learned Concerning the So Called Toxic Factor in Simple Bowel Obstruction Attending the Employment of Suction

The frequent use of suction in the treatment of adhesive obstruction has afforded an opportunity to study the reaction of these patients The pulse and temperature of patients with varying grades of obstruction remain normal usually during the suction period A low grade fever is observed initially in practically every instance This fever may come, in part, however, from the indwelling duodenal tube It is further noted that, there is *rarely a rise of pulse or temperature in any of these cases* during continuance of suction therapy, including those in which resort had to be made to operation following efforts at achieving conservative reduction (Fig 34) This is particularly significant for those patients needing subsequent operation, representing in almost every case complete obstructions, which in many instances *were not relieved for days In this latter* group of patients, however, it is to be noted that accompanying operation, there was always a brisk reaction in pulse and temperature which subsided slowly (Fig 38) This occurrence suggests that operation probably was deferred too long in some of these cases

(1926) studies on the angle of inclination of the Eustachian tube explain the intolerance of the infant to the inlying duodenal tube (Fig 43) The duodenal tube can not be left in place for long stretches of time in the infant because of its predisposition to development of salpingitis of the Eustachian tube with consequent otitis media This condition has been encountered rarely in the employment of gastric siphonage in the treatment of distension, but in a series of infants, with so called congenital hypertrophic pyloric stenosis reported previously (1931) fed by the drip

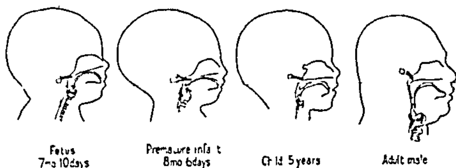


Fig 43—The angle of inclination of the Eustachian tube in the fetus infant child and adult (Unpublished data from Ph.D thesis in Anatomy 1926 W T Peyton) The greater ease with which infection develops in the Eustachian tubes of infants and children attending use of the indwelling duodenal tube is apparent from these diagrams

method through a small urethral catheter led into the stomach, this complication frequently developed Were it not for this difficulty, undoubtedly a large number of infants with this condition who present themselves for treatment at the eighth to tenth week could be carried to a satisfactory termination without operation The term stenosis is really a misnomer for there is no stenosis in the true sense—the condition being due essentially to an unusual hypertrophy of the circular sphincteric muscle of the pylorus And it is well known that, after the fourteenth to sixteenth week, the condition clears up spontaneously not infrequently The stomach in this condition apparently is capable of handling drip feedings over a twenty-four hour period whereas frequent small feedings at three to four hour intervals give rise to regurgitation

There is another complication, however, that should be mentioned, which comes occasionally after protracted use of the indwelling duodenal tube, viz laryngeal edema This complication has been observed a few times in this clinic In the survey in 1938 comprising the results of the first 7 years of suction treatment of intestinal obstruction of mechanical origin, two such patients had been seen Iglauer of Cincinnati and Molt of Indianapolis (1939) reported 12 cases, ten of which came under their supervision The authors, however, are laryngologists and complications of this type occurring in a community would, in consequence come to their notice At the time of the 7 year study, in this clinic, it was estimated that more than

Lessons Learned About Vomiting

The employment of suction in the postoperative period, to obviate distension, as well as experience gained in its use in the alleviation of distension in the course of peritonitis, has thrown interesting light and evidence on the cause *of vomiting in these disorders* The incidence of vomiting in a large series of postoperative cases treated by suction was strikingly diminished as contrasted with a similar group of cases in which suction was not employed Whereas the incidence of vomiting in a series of 42 cases of peritonitis not treated by suction was 62 5 per cent, in another similar group of 43 cases treated by suction, it was 19 per cent In another group of 15 patients with peritonitis treated with suction in which it was made certain that the tube was in the duodenum and perforations were *present in the gastric as well as duodenal portion* of the catheter, there was minimal vomiting in two cases

It would appear in consequence that the most important factor in the genesis of postoperative vomiting as well as that of peritonitis is retention in the stomach and upper small intestine The same cessation of vomiting is observed likewise in mechanical obstructions attending satisfactory decompression of the upper reaches of the gastro intestinal tract In such instances, however, this occurrence is not so unexpected for the vomiting is largely the *evacuation of material regurgitated into the stomach from a* lower level in the alimentary canal In uremia and other states in which gastric retention is not present, the employment of duodenal suction is of no benefit in relieving nausea or vomiting

F COMPLAINTS OF PATIENTS RELATING TO THE EMPLOYMENT OF SUCTION

About the only common complaint of patients on whom prolonged siphonage is being used is the sticking feeling or soreness of the throat caused by the tube This is a variable factor, but most patients express some dissatisfaction over it In some measure, the instillation of nasal oil or argyrol through the nose into the throat assuages this distress Occasionally it has been necessary to spray the oral pharynx with cocaine solution to allay the irritation caused by the tube In the main, however, it has been *the patient who has had least need of suction* who has complained most bitterly about the tube The patient who may be inclined at first to swear at the tube, later often swears by it In a few patients in whom a duodenal tube has been continuously in place for six weeks or longer, *no objective* evidence of any harmful effects, such as pressure erosion have come to the writer s notice Similarly, no case has been noted where ulceration of the gastric or duodenal wall has been caused by an indwelling catheter (See below)

It should be mentioned however that infants are intolerant of the tube being long in place because of the tendency to the development of otitis media attending prolonged suction, whether the tube is inserted through *the mouth or nose* This complication has not been observed in adults or children, however, children occasionally and adults less frequently, complain of "earache" attending prolonged use of the duodenal tube Peyton's

in Table XVIII This table gives some indication to what extent sodium chloride has to be supplied attending use of the inlying catheter

Coller and Maddock tabulate the approximate sodium chloride content of fluid losses from the intestinal canal as follows

TABLE XVIII.—THE CONCENTRATION OF SODIUM CHLORIDE IN VARIOUS FLUIDS (Coller and Maddock 1940)

	Variation in Sodium Chloride Concentration gm per liter	Average Sodium Chloride Concentration gm per liter
Vomitus	1.2 to 6.2	3.3
Gastroduodenal suction drainage	1.9 to 7.9	5.7
Hepatic bile	3.5 to 6.4	5.1
Intestinal fistula drainage	3.0 to 8.8	5.2
Diarrheal stools	3.7 to 5.2	4.3
Physiological saline solution		8.5 U.S.P

Three to four thousand cubic centimeters of para oral fluids are usually adequate in amount If the fluid aspirations, which are to be deducted from the total fluid intake, are great, more para oral fluids may be required (see page 133) It is in high obstructions particularly, that dehydration and dechlorination are likely to be prominent features requiring the more liberal administration of fluid In the writer's experience, normal saline solution meets satisfactorily the tissue needs for fluid As has been abundantly pointed out by a number of investigators, no other combination of the sodium or the chloride ions appears suitable Because the body stores of glycogen from which glucose is mobilized are quickly depleted in starvation, it is a good plan to add enough glucose to the saline solution to make a 5 per cent glucose solution As the initial dehydration is repaired by the liberal administration of saline solution and a satisfactory urine output follows, it is wise to alternate the infusion of glucose in saline solution and distilled water The continued administration of saline solution beyond the requirement of the tissues leads to retention of sodium chloride and water in the intercellular spaces with resulting edema The specific gravity of the urine is a valuable help in this matter (see page 133) Of the various routes in which this fluid may be given, viz , proctoclysis, subcutaneous, and intravenous, the latter is the most practical A satisfactory manner of giving the requisite fluid is to divide the total amount fairly evenly between a morning and evening administration, giving usually 1,500 to 2 000 cubic centimeters at a time—the infusion being continued over an interval of an hour and a half to two hours each time In this manner, the greater portion of the glucose is made available for the requirements of the body and no ill effects from too rapid administration of fluid will be apparent When intravenous infusion is impractical because the subject is small or the veins are difficult to locate, the fluid can be given subcutaneously—probably best under the fascia lata on the external aspect of the thigh

5,000 patients in the clinic had worn indwelling duodenal tubes for variable periods of time

A disquieting feature, however, is that in some of the patients reported by Iglauer and Molt, the complication was observed when the tube had been in place for periods of time as short as two days The writer has the impression that fever, of a degree or more Fahrenheit, attends employment of the indwelling duodenal tube, not uncommonly Yet, with frequent instillation of nasal oil (at least 4 times daily) into the nostrils, and, with the swallowing movements attending the drinking of water, this complication, it must be said, is by no means frequent The experience of the past few years supports that reported previously in the 1938 survey

Iglauer and Molt believe that the laryngeal edema results from a primary necrosis of the anterior wall of the esophagus, at its attachment to the body of the cricoid cartilage Over the median ridge of the cricoid cartilage, *the muscular coat of the esophagus* is thin, and, *fails* to provide a good cushion between mucous membrane and cartilage Ulceration may lead to perichondritis with subglottic stenosis and fixation of the arytenoids *Temporary tracheotomy may become compulsory in patients* presenting evidences of respiratory obstruction

G THE ADMINISTRATION OF FLUID WHILE SUCTION IS IN FORCE

The only practical and reliable measure of the amount of fluid, which it is necessary to give, is the daily urine output Coller and Maddock, who have given this matter special study, believe that, the urine output in a 24 hour period should approximate 1,500 cubic centimeters The writer's practice over a period of many years has been to insist on the administration of enough para oral fluid to patients who have been operated upon to insure a minimum daily urinary output in adults of 700 to 1,000 cubic centimeters Experience has shown that this amount is also adequate and satisfactory for patients with acute intestinal obstruction In infants and children in whom the collection of urine can not be done *regularly*, the requisite amount of fluid has to be determined by the wetting of diapers and more general considerations, such as the turgor of the skin It is *obvious that they require less fluid, 100 to 150 cubic centimeters* per kilogram of body weight is usually adequate The administration of fluid in excess of that mandatory to maintain a satisfactory water balance in the tissues does not appear to be desirable It would scarcely seem necessary to utter the warning that, with the employment of suction in the treatment of stasis in the gastro intestinal canal, it is particularly important to be alert concerning tissue hydration Failure on the part of surgeons to insist that the urine output be determined and carefully summated for every 24 hour period until convalescence has become well established is largely responsible for any difficulties on this score The daily urine output in the early postoperative period and in *all* patients under *observation because of* acute abdominal conditions should be as carefully charted as the temperature (Fig 72) The sodium chloride losses attending drainage of various types of *fluid from the* intestinal canal and its appendages is indicated

in Table XVIII This table gives some indication to what extent sodium chloride has to be supplied attending use of the inlying catheter

Coller and Maddock tabulate the approximate sodium chloride content of fluid losses from the intestinal canal as follows

TABLE XVIII—THE CONCENTRATION OF SODIUM CHLORIDE IN VARIOUS FLUIDS (Coller and Maddock 1940)

	Variation in Sodium Chloride Concentration gm per liter	Average Sodium Chloride Concentration gm per liter
Vomitus	1 2 to 6 2	3 3
Gastroduodenal suction drainage	1 9 to 7 9	5 7
Hepatic bile	3 5 to 6 4	5 1
Intestinal fistula drainage	3 0 to 8 8	5 2
Diarrheal stools	3 7 to 5 2	4 3
Physiological saline solution		8 5 U.S.P

Three to four thou and cubic centimeters of para-oral fluids are usually adequate in amount If the fluid aspirations, which are to be deducted from the total fluid intake, are great, more para oral fluids may be re quired (see page 133) It is in high obstructions particularly, that dehydration and dechlorination are likely to be prominent features requiring the more liberal administration of fluid In the writer s experience, normal saline solution meets satisfactorily the tissue needs for fluid As has been abundantly pointed out by a number of investigators, no other combination of the sodium or the chloride ions appears suitable Because the body stores of glycogen from which glucose is mobilized are quickly depleted in starva tion, it is a good plan to add enough glucose to the saline solution to make a 5 per cent glucose solution As the initial dehydration is repaired by the liberal administration of saline solution and a satisfactory urine output follows, it is wise to alternate the infusion of glucose in saline solution and distilled water The continued administration of saline solution beyond the requirement of the tissues leads to retention of sodium chloride and water in the intercellular spaces with resulting edema The specific gravity of the urine is a valuable help in this matter (see page 133) Of the various routes in which this fluid may be given, viz , proctoclysis, subcutaneous and intravenous, the latter is the most practical A satisfactory manner of giving the requisite fluid is to divide the total amount fairly evenly be- tween a morning and evening administration, giving usually 1,500 to 2 000 cubic centimeters at a time—the infusion being continued over an interval of an hour and a half to two hours each time In this manner, the greater portion of the glucose is made available for the requirements of the body and no ill effects from too rapid administration of fluid will be apparent When intravenous infusion is impractical because the subject is small or the veins are difficult to locate, the fluid can be given subcutaneously—probably best under the fascia lata on the external aspect of the thigh

It is difficult to be certain of absorption of fluids administered by proctoclysis

The fluid permitted by mouth is usually immediately re-aspirated when siphonage is in force In the employment of suction to prevent distension after operation, it has been the writer's practice to permit the patient a daily oral intake of 2,400 cubic centimeters of water More, undoubtedly, *could be taken without harmful effects* Unlimited oral intake of fluid, however, necessitates frequent changing of the bottles Observation has shown also that this needless washing of the walls of the stomach results in greater loss of chlorides In mechanical obstructions, the writer has tried both the ingestion of large quantities of water by mouth as well as total withholding of oral intake of fluid In the main, it is his impression that a more rapid decompression is to be obtained by keeping the oral intake well within the limits specified above

It is obvious that the fluid taken by mouth while suction is in force should be clear fluids Apart from the consideration that fluid ingested is immediately re-aspirated, any *clear fluid such as tea, ginger ale grape* juice, or strained orange juice may be permitted On the whole, however, as long as siphonage operates continuously, water is the best fluid When suction can be interrupted and concern exists over the adequacy of the caloric intake, lactose can be added without making a refreshing drink sickeningly sweet as would the liberal addition of sugar Because of the clotting of milk in the stomach, it can not be taken by mouth as long as *suction is necessary Whereas, carbon dioxide is formed in rather large* amounts in the digestion of carbohydrates, such gas is readily absorbed, and, in the absence of distension, no contra indication exists to their in gestion Gaseous distension comes about more through the item of im paired intestinal motility, the nature of the food ingested is not so im portant as long as it can be removed, absorbed, or transported

With employment of the Miller-Abbott tube, once it has descended well into *the bowel, the patient may eat most everything and the same neces* sity for balancing the fluid intake by the liberal para oral administration of fluid does not obtain Decompression, having been achieved, the aspirations of fluid from the bowel will be small in amount

H HISTORY OF USE OF DUODENAL TUBE

Paine (1934) has traced the history of the development of the duodenal tube and its employment in the therapy of abdominal lesions The important items recounted by Paine are listed in the accompanying table Development of the Miller Abbott long balloon tipped tube has occurred since Paine's paper was written

I RECTAL SIPHONAGE

On the whole, it can be said that rectal siphonage is not satisfactory In the main, the indication for its employment concerns cases with colonic distension, when such distension is great and is due to mechanical causes,

TABLE XIX.—DEVELOPMENT OF INSTRUMENTS FOR GASTRIC AND DUODENAL INTUBATION

1790	John Hunter of London reported the use of stomach tube to feed a patient with paralysis of the muscles of deglutition
1813	Philip Syng Physick reported the successful use of a urethral catheter in washing out the stomach of an infant who had ingested laudanum
1822	Jukes of London reported successful use of a "stomach pump" in removal of ingested poisons on dogs He himself swallowed 10 ounces of laudanum and evacuated it with the pump without suffering harm
1869	Kussmaul of Heidelberg described use of the "American stomach pump" (refers probably to the stomach tube and pump constructed by Dr Wyman of Boston) in evacuating the stomach of patients with pyloric stenosis
1896	Hemmeter of Baltimore reported intubation of the duodenum
1910	Max Einhorn and Maurice Gross of New York City reported simultaneously development of simple tubes permitting duodenal intubation
1921	Levin of New Orleans described the smooth catheter tipped duodenal tube
	Clinical Application of the Duodenal Tube
1910	Westermann of Germany reported treatment of 15 cases of peritonitis with gastro-intestinal stasis by continuous siphonage drainage of the stomach by means of a duodenal tube passed through the nose
1911	Kappis also of Germany reported 10 similar cases treated in the same manner and endorsed the method enthusiastically
1916	Kanavel of Chicago attached water-seal drainage to the inlying duodenal tube to enhance the efficacy of siphonage
1921	Matas of New Orleans advocated general use of postoperative siphonage to combat distension
1925	Ward of San Francisco described attachment of a water siphon apparatus attached to an inlying duodenal tube to afford a source for continuous active suction
1931	Wangensteen of Minneapolis described decompression of three patients with acute mechanical obstruction of the small intestine by suction applied to an inlying duodenal tube
1933	Paine and Wangensteen of Minneapolis demonstrated the superiority of constant suction over siphonage in evacuating the upper reaches of the gastro-intestinal tract after operation
1933	Wangensteen and Paine of Minneapolis reported the first series of cases in which suction had played a major role in the management of patients with acute mechanical obstruction of the small intestine (32 cases with 5 deaths a mortality of 15.6 per cent) (Twenty were treated by suction alone with 2 deaths—5 per cent mortality)
1934	Miller and Abbott of Philadelphia reported development of a two-way balloon tipped long duodenal tube for intubation of the small intestine
1938	Abbott and Johnston reported decompression of instances of mechanical obstruction with use of the long Miller Abbott tube

a direct operative attack on the colon is indicated, in those instances of ileus due to peritonitis, where the colon participates in a general distension irrigation of the colon is contra indicated There is undoubtedly a limited group of cases in which the method of rectal siphonage employed by Pratt is of value, viz , suction alternated with fluid injections employing a small inlet catheter and a large outlet tube The sigmoid and splenic flexures of the colon in addition to the feces afford obstacles to invariable success with the method In carcinomas of the rectal ampulla causing obstruction, decompression can be effected occasionally by passing a catheter through a proctoscope beyond the point of obstruction

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CHAPTER VII

OPERATION IN BOWEL OBSTRUCTIONS

A SURGERY THE MAINSTAY OF THERAPY

SINCE the advent of anesthesia and the birth of aseptic surgery, operation has been the chief remedial agent in dealing with bowel obstruction It remains still the mainstay of therapeutic measures in the therapy of obstruction Despite improvements in the technique of all surgery, the results of operation for bowel obstruction have shown no such betterment Yet, the results of early operation, on the whole have been in accord with issues obtained in dealing with other acute abdominal lesions

The penalty of late recognition of bowel obstruction is apparent in every statistical study of the subject Yet whereas ten or twelve hours delay between the occurrence of perforation of a duodenal ulcer and its closure begins to have an ominous significance, whether in the hands of the average or the most expert and facile surgeon a much wider latitude is accorded the patient with bowel obstruction in both time and matters of circumstance A patient with an acute adhesive obstruction of simple nature of 48 72 or more hours duration has a good chance of recovery with well executed surgery Whereas the time element is probably the most significant item in the determination of the issue in the surgical treatment of a perforated duodenal ulcer, the choice of operative procedure and the *kind* of surgery practiced in the relief of late bowel obstruction are all important. Early in the course of obstruction, the experience of the surgeon does not affect the nature of the outcome so decidedly Late in the obstruction, *all* depends on the manner of release of the obstructing mechanism late perforations of duodenal ulcers are doomed usually by the time element alone and the skill of the surgeon matters but little

Selection of Cases for Operation

With the single exception of reduction of intussusception by conservative means operation until recently has been the only remedial agent of value in treating patients with bowel obstruction Operation still is and probably will continue to be the chief mainstay of therapy in most forms of bowel obstruction It is, however, apparent that some cases need not be operated upon, particularly patients with partial simple obstruction of the small intestine The accompanying diagram indicates in general terms the treatment indicated in the various clinical varieties of obstruction (Table XX)

The classes of cases which demand urgent operation are (1) instances of strangulating obstruction and (2) acute obstruction of the colon with great distension All patients with simple obstruction in which the nature of the occlusion is known to be such that operative relief will be necessary,

should be subjected to early surgery Among this group are the congenital intestinal atresias of the new born and imperforation of the rectum and anus, conditions which are usually readily identified Strictures of the small intestine, which usually give rise to a picture which identifies the disaster, usually can be treated satisfactorily by suction and operated upon in an unobstructive phase Physiologic obstructions, viz, spastic and

TABLE XX.—CLASSIFICATION AND TREATMENT OF INTESTINAL OBSTRUCTIONS

(The consideration of special obstructions in Part IV will follow this outline)

Clinical Classification	Pathologic Classification	Treatment
I Mechanical A Narrowing of lumen 1 Strictures of bowel wall a Congenital {Atresia, Imperforate anus} b Acquired {Inflammatory, Traumatic, Vascular, Neoplastic} 2 Obturation 3 Compression from without (especially pelvis and retroperitoneal duodenum)	Simple except in neoplastic strictures of the colon	Operation preceded by suction for decompression in late cases except in occlusion of the colon
B Adhesive bands {Congenital, Inflammatory, Traumatic, Neoplastic}	Simple or strangulation	Suction operation for persistent obstruction and in strangulation
C Hernia 1 External 2 Internal D Volvulus E Intussusception F Errors in development of the intestine giving rise to intestinal obstruction	Strangulation	Early operation
II Nervous (physiological imbalance) A Inhibition ileus-(paralytic) adynamic B Spastic ileus-dynamic	Simple	Suction
III Vascular Thrombosis and embolism of mesenteric vessels	Strangulation	Early operation

inhibitive (paralytic) ileus need operation rarely Occasionally, the former, when the distension concerns the colon, can not be distinguished from mechanical obstruction of the colon On more than one occasion the writer has operated upon a patient with spastic obstruction of the colon with enormous distension under the impression that the lesion was probably an obstructing malignancy in the pelvic colon To treat a patient, with enormous colonic distension due to organic obstruction of the pelvic colon, conservatively as a case of spastic ileus would be disastrous All acute

mechanical obstructions which do not respond favorably to a period of trial with suction should be operated upon

General Considerations in the Selection of Operative Procedure

The chief factors which influence the choice of procedure in dealing with bowel obstruction are these (1) Is the obstruction early or late? (2) Is it simple or strangulating in character? In simple obstructions, the time element figures prominently in the decision as to what should be done Strangulating obstructions, on the contrary, permit of no alternatives in the choice of procedure except as indicated by the condition of the bowel In any event the imprisoned gut must be released from its constriction and the viability of the gut determined If non viable, it must be excised, if the integrity of the gut wall is maintained mere release of the bowel suffices usually In instances where uncertainty prevails as to the viability of the gut the procedure depends largely upon the gravity of the doubt entertained concerning the chances of survival of the bowel wall, if slight a proximal enterostomy is in order, if great, the bowel in question should be exteriorized or preferably excised

The lateness of the obstruction and its nature can be determined largely by clinical and x ray evidence Whether an obstruction is late or early is not wholly a matter of time A partial obstruction of a week's standing may not be as advanced as one which is of only 48 hours duration but complete Yet, patients may die of a partial obstruction The degree of distension as revealed on an x ray film, together with the patient's general condition, determines largely whether an obstruction is late or early

Similarly a simple or strangulating obstruction may be differentiated with considerable, though by no means absolute, accuracy by the diagnostic criteria described previously If any doubt remains the opening of the abdomen serves to distinguish A strangulating obstruction is heralded by a bloody peritoneal fluid and an infarcted gut Hemorrhagic peritoneal fluid is observed so rarely in simple obstruction that its mere presence is indication that search should be made for strangulated bowel The time element figures prominently in the determination of the procedure in most cases of strangulating obstruction The only obstruction of this variety in which vessels are actually blocked is mesenteric thrombosis or embolism, all other strangulating obstructions may be regarded as simple in nature if the influence of the agent compromising the blood supply is removed early

B CHOICE OF OPERATIVE PROCEDURE

The available operative procedures from which the surgeon has to choose in relieving obstructions, apart from special methods described under the caption of individual obstructions, are (1) division of adhesions and release of the bowel from an entangling or compressing agent, (2) enterostomy, (3) exteriorization of the bowel with the establishment of a complete external fistula, (4) the making of an entero anastomosis around the obstructing mechanism, and (5) excision of the obstructed

segment of bowel and the establishment of continuity by *primary anastomosis*

The outcome in bowel obstruction is determined as much by the operative procedure chosen by the surgeon as by *the manner of its execution* In part, the choice of operation is already decided for him by the type of obstruction present In strangulating obstructions, save in most unusual circumstances, whether the bowel is viable must be *definitely ascertained*, release from the strangulating mechanism must be obtained and, if the bowel is not viable, it must be excised The only choice granted the surgeon is whether he will exteriorize the devitalized bowel and establish a temporary complete external fistula or re establish its continuity by primary anastomosis Alternative procedures manifestly are not applicable in such instances as may be invoked when *the continuity of the gut alone is obstructed* without interference with its blood supply There may be occasions when it is wiser to decompress the bowel proximally by enterostomy and to leave the strangulated segment, *obviously, however, this procedure* could only be effective in those instances in which the bowel involved actually is viable, and when reduction of intra enteric pressure in the bowel proximal to the *incarceration can affect favorably the blood supply of the strangulated loop* In intussusception, when it is evident that a portion of the intussusception is non reducible or non viable, the employment of enterostomy is fully justified occasionally because the intestinal segment with compromised blood supply lies within a normal ensheathing cylinder, furthermore, the only obstruction to intestinal continuity is constituted by the compression of swelling and edema, proximal enterostomy in such an instance may permit of automatic restitution of interrupted intestinal continuity Obviously there still is much left to chance (1) the possibility of hemorrhage with sloughing of the telescoped bowel and (2) the necessity for re operation To be certain, these are not so serious, and if such a compromise measure appears to be the wisest expedient, it still holds out a reasonable chance of success When this same procedure is applied to a strangulated segment lying within the peritoneal cavity unprotected by an ensheathing cylinder of normal bowel, it is evident that unless the imprisoned bowel can maintain its blood supply, this instrument is doomed to fail An operative procedure must have a reasonable chance of a favorable termination The one which affords the patient the greatest promise with the least risk should be selected always If at all feasible, the writer prefers primary resection, employing the closed anastomosis, to the compromise measure just described

In simple obstructions, particularly where a choice of procedure may often be made, it is of the utmost importance that the surgeon choose wisely The *essential requisite* for a successful issue is that the operation which relieves the distension or restores simultaneously intestinal continuity must be done *aseptically* The great significance *of this factor for* the safety of the patient can not be overemphasized Another important consideration is that the procedure of least magnitude is most easily withstood by the patient *It is well known that patients with acute bowel*

obstruction tolerate extensive manipulation of the bowel poorly Just wherein the danger to the patient lies is not exactly known That this hazard menaces recovery is apparent in the operative mortalities of those surgeons who favor and insist upon removing the obstructing agent or releasing the gut from its influence wherever possible The surgeon naturally feels more at ease over the eventual result when he has left little to chance by the direct operation of election He who has weighed carefully the great gain which is to be had by draining the distended bowel in simple obstruction knows how favorably chance inclines to a promising outcome attending employment of decompressive types of operation Immediate evacuation of the bowel by stripping out its content is not necessary in the lesser obstructions and may be a perilous expedient in the late ones Despite the successes which have been achieved by its employment in the hands of experienced surgeons it is not a method to be recommended for general use Moreover an aseptic decompressive enterotomy will be described below under Caption Q directed at evacuation of the distended bowel at operation, without the hazards attending employment of the Monks Moynihan stripping procedure

Much has been written concerning the role of anaerobic infection and the toxins of the Welch bacillus in bowel obstruction The experience of the writer leads him to believe that there is not much to be feared from this agency as long as the bowel is viable and no peritoneal contamination has occurred

Simple Obstruction

In early cases, the operation of election may well be done, that is, the exact site and nature of the obstruction may be sought out When the obstructing agent is extrinsic to the gut wall, the gut is to be freed from it When an intraluminal obstruction, such as a gallstone or an intrinsic obstruction in the gut wall as a stricture, are present the exact mode of dealing with the occlusion is not so obvious All wide openings or anastomotic procedures on the gut are to be avoided wherever possible because of the risk of peritonitis The gallstone may occasionally be pushed back from its site of incarceration to a higher level and crushed If the gut is opened for its removal, great care is to be observed to avoid spillage An aseptic enterotomy for removal of an obstructing gall stone is described in Chapter XIV In the instance of benign strictures in the gut wall enterostomy followed by excision in a non obstructive phase is probably the wisest choice of procedure In malignant strictures of the small intestine, especially when low in the ileum, preliminary exterioriza tion as is done with infarcted bowel followed by secondary anastomosis is the procedure of election in the presence of malignant strictures high in the jejunum, a primary aseptic entero anastomosis about the lesion fol lowed by its excision in a non obstructed phase probably carries least risk for the patient Fortunately, in many acute obstructions of this type, decompression can be accomplished by suction applied to an indwelling duodenal tube

The judicious choice of operation in late cases of simple obstruction will do more to lower materially the operative mortality of bowel obstruction than any other group of factors Decompression by enterostomy or colostomy, depending upon whether the small intestine or colon is obstructed, is the operation of choice In late simple obstructions many lives are sacrificed because of the anxiety of the surgeon to do a complete operation This is particularly notable in instances of complete adhesive obstruction of several days standing In such instances, adhesive bands have become fused virtually with the gut wall Detachment or release of the adhesive bands results frequently in opening the gut with escape of its highly infectious content into the peritoneal cavity Anything, which the surgeon might then do, cannot favorably influence the situation The patient is thrown upon his own resources which are almost consistently inadequate to enable him to cope successfully with the peritonitis which follows invariably To be certain, recovery has attended spillage from the intestine by the surgeon in operating upon a distended and obstructed bowel in this clinic Far more frequently, however, such contamination in the presence of obstruction presages an unhappy ending

The effect of a band upon the gut was studied in a number of dogs and rabbits by passing a suture or the tape ligature in the manner of a U around the ileum In turn it was brought out through the abdomen, threaded through two eyes of a button, and tied on the anterior abdominal wall Such a ligature may cut through in four to six days, depending on how tightly it is tied The gut wall above the site of occlusion though dilated had firm texture that beneath the tie was thin and extremely friable, indicating the hazard of manipulating it Whereas frequent perforation of a loop so obstructed did not occur spontaneously, slight traction exerted upon it frequently caused rupture and leakage The reason that contamination, from spillage from the obstructed intestine, is so much more hazardous than from the normal, is because of the well known tremendous increase in bacteria in the fluid content of the obstructed bowel

It is the conviction of the writer from his own experience in performing enterostomy for late simple obstruction that, provided the gut can be tapped aseptically without the slightest trace of spillage, the patient gets well usually, no matter how distended the bowel or how ill the patient is One hears it said not uncommonly or finds it related that the gut was dilated to the extent that its wall had become paralyzed and in consequence enterostomy was a failure Undoubtedly there is an optimal grade of stretch for the muscle of the gut at which its contractile activity works to the best advantage, obviously this is not a fully collapsed gut, neither is it one dilated to its utmost capacity All smooth muscle, moreover possesses a great capacity for accommodating itself to varying grades of distension, as has been pointed out previously, unless the circular muscle of the gut is torn one would expect it to contract down Actually this is what happens invariably, when one isolates a tremendously distended segment of bowel between two rubbber covered intestinal clamps, as soon as the content of the very much thinned out

gut is aspirated, the bowel wall collapses immediately, and in a few seconds the gut wall becomes also considerably thicker owing to the contraction of its circular muscle

In late simple obstructions with considerable distension, therefore, failures with enterostomies are not because of the inadequacy of the method but rather because the usual enterostomy is not done aseptically Van Beuren and Smith (1927) state that there is as much chance to improve the patient with ileus by enterostomy as there is to cure a patient with fatal chemical poisoning by the same means when the poison has been absorbed Certainly, this statement is in uncompromising conflict with what we know about the effects of obstruction as well as with experience in the performance of enterostomy The mortality of enterostomy in late cases of simple obstruction in which the bowel is viable should not be 70 (Scudder Zwemer and Whipple 1938) 77 7 or 90 9 per cent (Van Beuren and Van Beuren and Smith 1920, 1927) When aseptic enterostomies are done the mortality will approach zero in direct proportion to the success with which the technique is carried out aseptically Despite the fact that enterostomy will always be done upon the *worst cases of* simple obstruction upon which one does not dare to do any other procedure if the gut is viable, the mortality should be low

To be sure in a few instances an enterostomy may have to be followed by a subsequent direct attack upon the obstructing mechanism even in adhesive obstructions When the bowel has been decompressed by external drainage and when the gut wall will not be opened so easily inadvertently, as it is in an obstruction of three or four days standing a second operative attack may be contemplated by the surgeon with far greater equanimity, if found necessary

C PRE-OPERATIVE PREPARATION

It is extremely important to know whether the patient is a good risk for operation This determination rests essentially upon an evaluation of the patient's general physical condition Dehydration and dechlorination, common accompaniments of obstruction of the small bowel, owing to repeated vomiting, must be combatted with adequate replacement of water and electrolytes (sodium chloride) The fluid requirements of obstructed patients are discussed at length in the chapter on pre- and post-operative treatment Inasmuch as the time factor is of importance in preparing an obstructed patient for operation the intravenous route of infusion of saline solution constitutes the method which accomplishes the objective most quickly Obstructed patients who have had considerable vomiting present usually evidences of hemoconcentration and are, as a rule oliguric In addition, the suggestions of Coller and Associates (1938), with reference to the salt deficit estimated from the plasma chlorides are to be kept in mind, in the administration of saline solution to dechlorinated patients (p 132)

If the obstruction is believed to be strangulating in character, and the pulse is hurried and the blood *pressure is hovering around potential*

shock levels (100 mm Hg or less), transfusion of blood or plasma is mandatory before operation is undertaken More and more, surgeons have been becoming increasingly alert to the great importance of combatting blood loss adequately To operate upon a patient with volvulus or intussusception or other variety of strangulating obstruction, without meeting adequately, preoperatively, the loss of blood occasioned by the strangulation, invites disaster and is foolhardy Only *the planned procedure, which meets all the known exigencies of the situation, affords* promise of success The difference between success and failure is often only a hair's breadth, but the difference between a live man and a dead one is real

It is important to know that the stomach is empty Suction, applied to an *inlying duodenal tube, plays such an important role in the management* of obstruction that, no patients are sent to the operating room without the catheter being fastened in place It is a good plan to have suction in force during operation to avoid vomiting and regurgitation of vomitus into the lungs, the most frequent cause of postoperative pneumonia A set *of suction bottles, as employed in the decompression of patients with* bowel obstruction should be in every operating theater In infants and children, in whom the urinary bladder is practically an intraperitoneal organ, it is important to be certain that it is empty—particularly when fluid has been given liberally preoperatively

In *brief, the state of hydration of the patient, the status of the* circulation, the condition of the stomach and the urinary bladder are the items which demand particular attention before operation If an hour or more is to intervene between admittance to hospital and operation, it is well to prepare the skin of the patient's abdomen in the ward Washing and shaving consume time and should be done with care Gentle sponging of the skin with benzine and ether dissolves the grease and permits more effectual action of the antiseptic later to be applied before operation As a final step in the preliminary preparation of the skin on the wards, it is well to apply a sterile dressing, a small quantity of alcohol being poured upon the undermost layer of gauze Every caution is to be observed yes not only to preserve as absolute an asepsis as possible during the performance of the operative procedure, but every detail relating to the operation must be scrutinized from the standpoint of meeting the *inflexible demands of* rigid asepsis and antisepsis A very important consideration is the adequate masking of active participants in the operation as well as spectators Everyone should wear a mask covering nose as well as mouth Bacteria are too dangerous to warrant anyone assuming unnecessary peril for the patient *by failing to observe precautions which* are known to protect him Thoughtful preparation for operation intelligent and precise execution of procedures which maintain sterility of the peritoneum, and watchful post operative treatment constitute the best assurance for recovery from operation for bowel obstruction

Novak's solution has been employed to afford skin antisepsis as a substitute for iodine in this clinic for several years The formula appears in the accompanying table

TABLE XXI—FORMULA FOR NOVAK'S SOLUTION FOR PREPARATION OF SKIN PRIOR TO OPERATION

(Novak and Hall 1939)

Alcohol	525 cc
Acetone	100 cc
Water	375 cc
Tricresol	5 cc
Mercuric chloride	0 7 gm
Fosin Y	0.6 gm
Acid fuchsin	0.8 gm

D SELECTION OF ANESTHETIC

The ever present possibility that regurgitation might occur during the administration of inhalation anesthesia, despite pre-operative evacuation of the stomach made it almost mandatory that some other type of anesthesia be employed in the surgical relief of bowel obstruction The application of constant suction to an inlying duodenal tube before and *during* operation has changed all this If the patient is a satisfactory risk from the general standpoint, no contra indication to the use of inhalation anesthesia obtains

Spinal anesthesia is ideal because the relaxation afforded permits the surgeon to work with the greatest facility Despite this advantage of spinal anesthesia the writer is inclined to favor the employment of ethylene or cyclopropane re inforced by whatever amount of ether is necessary to

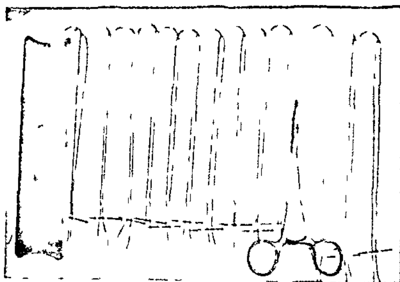


FIG 44—Intestinal suture pack Fine silk sutures mounted on small curved needles The shorter sutures are 32 cms in length and the longer ones are 40 cms (13 and 16 inches) The shorter are employed largely for the making of anastomoses About a dozen of each are mounted on needles before the operation begins Use of three such small needle holders shown here permit placement of sutures with despatch

obtain adequate relaxation A wide experience with this combination of anesthetic agents in a number of diverse conditions has convinced the writer that inhalation anesthesia administered skillfully, provides the greatest safety for the patient Advanced age does not constitute a legitimate exception The usual practice of this clinic, under the supervision of Dr Ralph Knight, Director of the Division of Anesthesia, is to induce anesthesia by the intravenous injection of pentothal sodium, a Magill intratracheal tube is then passed and adequate relaxation can be maintained by the administration of cyclopropane As small a dose of novocain as 100 milligrams injected into the subarachnoid space of the lumbar region has brought about fatal asphyxia, despite the use of all well known adjuvant measures to combat the dyspnoea It is particularly in the bad risk patient, where one would like to use spinal anesthesia that it appears to be most hazardous, in the satisfactory operative risk, spinal anesthesia may be employed with greater equanimity Until means are available of securing adequate anesthesia with safe doses, the advantages of spinal anesthesia will have to be put aside in favor of the increased safety and controllability of inhalation anesthesia In recent years, however, surgeons appear to have had more success and fewer unhappy experiences with spinal anesthesia This writer has continued nevertheless, to employ inhalation anesthesia Graham and Brown (1939) have stated, "a surgeon who operates upon a patient suffering with acute intestinal obstruction using inhalation anesthesia, if adequate facilities for spinal anesthesia are available, is guilty of malpractice" The practice of this clinic with inhalation anesthesia in the surgical management of acute intestinal ob struction does not substantiate this contention of Graham and Brown

An operation, such as enterostomy, can be done readily with infiltration of the field of operation with novocaine Some of the newer intravenous anesthetic agents, such as pentothal, are very satisfactory for short operations, but the writer has had no experience with their use in major abdominal surgery The choice of pre operative medication is related intimately to the choice of anesthetic agent Morphine is to be used with great caution at the extremes of life In infants and children and in patients over seventy years, because of the hazard of depressing respiration, morphine is to be avoided For the years between, the usual hypodermic administration of atropine sulphate (gr 1/150 or 0 4 mg) and morphine sulphate (gr 1/6 to 1/4, 10 to 15 mg) are satisfactory The pre operative administration of barbiturates, such as sodium amytal, may diminish the amount of anesthetic required Such preliminary medication, together with morphine and infiltration of the operative field with novocaine, frequently make it possible to omit the use of ether In a patient who is otherwise a good risk, however, ether is a safe anesthetic

It is well known, to be certain that ether lowers the threshold of sensitivity to histamine Unless considerable manipulation of the bowel is contemplated, however this factor in bowel obstruction is of no great concern, for there is no proof of abnormal absorption of histamine from the bowel lumen when its wall is viable Sperling and Kremen, however, noted that obstructed dogs tolerated the ill effects of "stripping" of the gut

better under anesthesia with barbiturates than under ether This same protective influence of barbiturates against strychnine poisoning is well known and has already been referred to

3 CONDUCT OF THE OPERATION

Before operation is undertaken everything necessary for the safe and expeditious conduct of the procedure should be in readiness Needles should be threaded with fine sutures that are immediately available All details of the operation are to be arranged beforehand The patient must be kept warm and loss of body heat guarded against during the operative procedure The blood pressure must be followed carefully by the anesthetist throughout It is a good plan to see to it that the legs of the patient are 6 to 10 inches (15 to 25 cms) above heart level This precaution guards against segregation of blood in the lower extremities during operation

It is to be remembered that whereas a patient with bowel obstruction does not present usually the distinguishing characters of shock viz, a depressed arterial blood pressure and a rapid pulse, yet the dehydration incident to vomiting makes him more susceptible to operative shock It is wise therefore, to look upon such a patient as being in potential shock and to treat him accordingly In placing the patient on the table it is always well to expose an extremity properly so that an intravenous infusion may be started on a moment s notice The practice in this clinic is to start an intravenous infusion when the patient is draped for operation, a leg vein usually being chosen for the purpose If the illness has been long enough to be reflected in the patient's general status even though saline solution has been generously administered pre operatively and the blood pressure is normal it is a good plan to give 300 to 1000 cubic centimeters of plasma solution during the operation It serves as an antidote against shock Should depression of the arterial pressure below 100 millimeters of mercury occur despite the infusion of plasma transfusion of blood is in order

The length of the operative procedure is not as important as the care with which it is executed In the ledger of failures and successes nevertheless, it is still a significant item and particularly in the late cases Yet hurry on the part of the surgeon must be discouraged If the patient has been prepared properly for operation the necessity for hurry becomes less urgent

The Incision

The location of the incision will be determined wholly by the type of operative procedure contemplated If the operation is somewhat in the nature of an exploratory operation a mid line subumbilical or a mid right rectus incision is usually best Most instances of small bowel obstruction can be approached satisfactorily through such an opening When operating upon children it is well because of the extrapelvic position of the urinary bladder, to make the incision somewhat higher In instances of small bowel obstruction, when it is quite clear that enterostomy is the operation of

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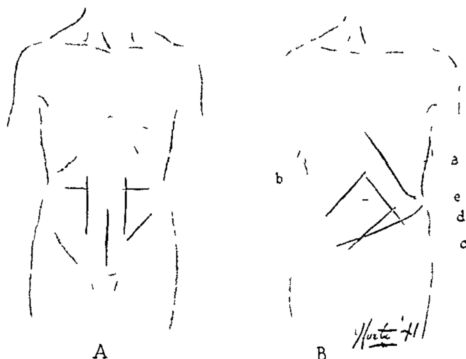


Fig 45—Abdominal incisions for operations upon the gastro-intestinal canal A Incisions employed in this Clinic for operations in the presence of acute intestinal obstruction Incisions should not be made in the immediate vicinity of a previous scar lest a distended adherent loop of bowel be opened on entering the abdomen Because many operative procedures for acute intestinal obstruction are in the nature of an exploratory operation the vertical incision is usually the approach of choice The transverse incisions are employed for decompressing the obstructed colon (see Fig 51) The left oblique incision is reserved for the occasional decompression made for acute obstruction When it is known that the distal lying lesion is operable cecostomy for acute colonic obstruction is never performed in this Clinic B Incisions for operations of election in the gastro-intestinal canal (a) left subcostal incision for gastric resection including total gastrectomy This incision affords superb exposure In the closure of the blind end of the duodenum it is to be remembered that the first portion of the duodenum is practically a midline structure (b) Incision employed by the writer for excision of the right half of the colon This incision is superior to a right or left Hoag incision shown in D in that it permits ready access to the transverse colon in the making of the anastomosis (c) incision suitable for excision of a lesion in the sigmoid flexure B or C suffice for resections of the small intestine (d) The Hoag incision—a physiologic incision with respect to preservation of nerve and blood supply useful in excision of the pelvic colon (e) Incision for lesions of the splenic flexure or descending colon the latter lesion demands mobilization of pelvic and splenic flexures This incision in the writer's experience affords excellent exposure The vertical incision is avoided studiously in all operations of election (see text)

choice, a short oblique incision over the left rectus muscle pulling the latter medially, constitutes a very satisfactory approach (*Ravdin*) The level of the incision with regard to the vertical spread of the muscle is to

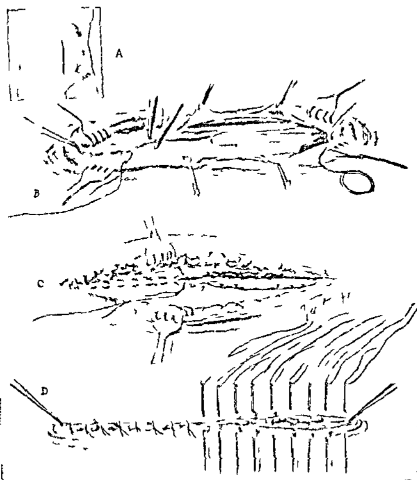


Fig 46—Closure of an abdominal incision A The incision B Closure of the peritoneum The McNealy viscera retainer is in place If the peritoneum and posterior rectus sheath do not come together easily the sutures should not be tied till all have been placed Traction on the sutures will then permit ready approximation usually C Closure of the anterior rectus sheath In the peritoneal closure employment of the Halsted mattress suture affords nice peritoneal approximation In the anterior fascial suture the single stitch is probably to be preferred to the Halsted suture shown here in that less silk is buried Interrupted silk sutures are employed throughout the closure Silk sutures possessing a 5 to 8 pound test strength are large enough Sutures need not be stronger than the tissues they approximate No retention sutures are necessary D The skin closure

be determined by inspection of the scout x ray film of the abdomen Obstruction of the lower reaches of the small bowel calls for a low incision, in which event it is best to make a vertical incision on either side of the linea alba In the absence of obstruction, the vertical incision has come to be regarded in this clinic, more and more, as unphysiologic—which, of

course, it is, inasmuch as the lateral pull of the oblique muscles of the abdominal wall is tending to pull the incision apart However, in the presence of distension, the paramount consideration is exposure, especially if the obstructive mechanism is to be sought out and liberated Hence, oblique or transverse incisions are not as useful, in the presence of great distension, as when distension is absent

When the obstruction is in the pelvic colon, the most satisfactory approach in the writer's experience, has been to place the incision directly over the transverse colon If it is a reasonable presumption that the lesion is carcinoma, which will necessitate further operative attack after the relief of the acute obstruction, a short transverse incision over the course of the transverse colon immediately to the right of the mid line is best, if, however, the operation is also somewhat in the nature of an exploration upon the pelvic colon, it is better to place the incision to the left of the mid-line The course of the transverse colon, as seen in a pre operative film made with a small opaque object fastened over the umbilicus, affords an excellent guide for the location of the incision through which the colon may readily present itself (Fig 50, p 199)

F LOCATING THE OBSTRUCTION

It is not always necessary to find the obstruction In the absence of a strangulating variety of obstruction, the most important consideration of operation is to relieve the distension and preserve the viability of the bowel wall The clinical picture when interpreted in the light of the x ray findings affords a means of identifying correctly the majority of obstructions before operation Strangulating obstructions must always be sought out their presence is heralded at operation by sanguineous peritoneal fluid

When an incision has been made that is somewhat in the nature of an exploration it is always wisest to first hold up the abdominal wall with retractors and look inside In disregarding this simplest of procedures, the obstruction may not be located without diligent and prolonged search with the hand in the abdomen Short of a routine "going over" of the entire intestine, it is the most efficient method by which to locate an obstruction in the small intestine The most distal portion of the colon which appears distended on the x ray film is the site to examine for obstruction in the large bowel

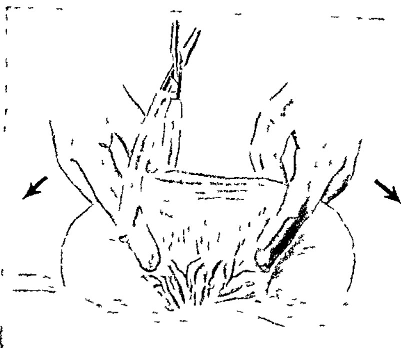
Many years ago Greig Smith pointed out that a distended intestinal coil in the proximity of the occlusion of the small bowel will usually present itself into the wound If the point of obstruction does not come within range of direct vision, pursuit of the coil in the direction that presents itself least readily will usually lead to the obstruction *The bowel* proximal to the obstruction is hyperemic as well as dilated, small bowel beyond the obstruction is collapsed When the obstruction does not immediately present itself and it would appear wise to ferret it out care should be observed to obviate evisceration With recognition of the value of the x ray film, when properly correlated with the clinical findings, in

affording orientation concerning the site of the obstruction, the old guide of first determining at operation whether the cecum is empty or distended is rarely of help Finding the obstruction in the small intestine when evidence points toward its being met with in the colon, or vice versa, should be a most unusual occurrence The descriptions of Monks, relating to fat deposition in the mesentery and the character of the arterial arcades, afford the surgeon helpful aids in orienting himself, with reference to the segment of small bowel concerned Similarly, the suggestions of Wilms to determine the level of the mesenteric attachment has some value in orienting the surgeon concerning the site of obstruction

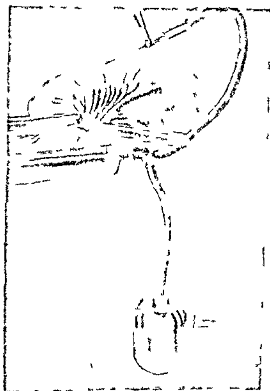
G ENTEROSTOMY

"Blind enterostomy has a wide field of usefulness in the treatment of mechanical obstructions of the small intestine There are those, however, who would abandon the operation altogether in favor of the more direct procedure of releasing the obstruction This writer cannot accept that view The time has come to speak of the mortality of the operation as well as of the disease He who arbitrarily looks upon the direct operation of election as being the operation of choice in most cases and rejects the compromise measures of drainage of the bowel accepts many unwarranted risks for his patients To be certain where an obstructing agency can be simply dealt with by the severance of an adhesive band which comes readily into view it should be done But the determination to find and release every obstructing mechanism and to restore intestinal continuity is an ideal objective but an unwise policy In cases of adhesive obstruction of several days' standing deliberate pursuit and division of adhesive bands is particularly likely to lead the surgeon into difficulty In the local reactions incident to distension such bands may become practically fused with the gut wall, such that separating or cutting them may result in opening the bowel, which unfortunate event almost invariably portends a fatal outcome The temptation to free the bowel from such bands may be great but if not prudently resisted, the surgeon may find like Pandora that opening of the box caused Evil to escape and only Hope remained, a most unreliable refuge in such instances

In order to be successful enterostomy must be well performed and without visible trace of soiling A valvular enterostomy with subsidence of the obstruction will close spontaneously on withdrawal of the catheter and even minimal temporary external drainage should be a rarity A deliberate high enterostomy as advised by Bonney and others is to be avoided it is better to place the drainage vent nearer the obstruction However as has already been pointed out (p 140) the amount of drainage through an enterostomy correlates directly with the grade of obstruction the level in the bowel at which the enterostomy was done does not determine the escape through the catheter A high enterostomy is not much more likely to succeed in effecting decompression than an indwelling duodenal tube



A



B

Fig 47—Operative decompression of distended small bowel to avoid spillage

A—Method of emptying a distended loop of small bowel preparatory to enterostomy It is well to aspirate *with a needle following the application* of clamps to make certain that the loop is empty

B—Alternate mode of emptying a distended loop of small intestine which can not be delivered and evacuated by the stripping process shown in Fig 47A The simple instrumentarium for this procedure should be available at every operation for acute intestinal obstruction

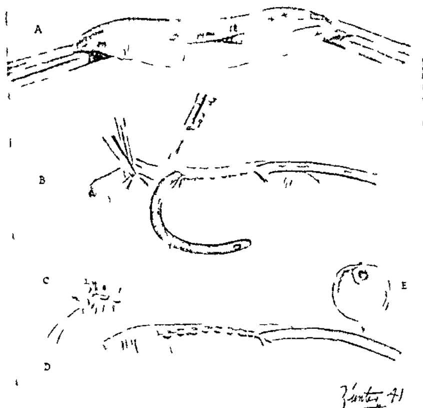
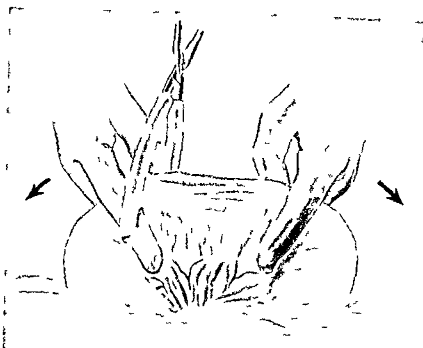


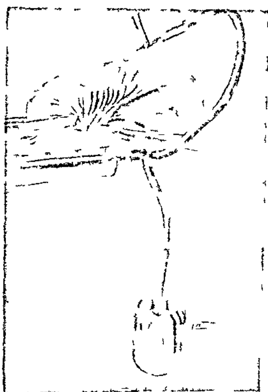
FIG 48—Technique of enterostomy A Contraction of a distended bowel upon evacuation of its content This occurs immediately and the bowel wall thickens surprisingly B A number 14 French catheter is laid upon the bowel and a few interrupted Halsted mattress sutures of fine silk makes a tunnel for the catheter Care must be taken to avoid spillage in puncturing the bowel The catheter is then anchored with a catgut suture to the bowel wall as indicated in Fig 50 C Employment of the 3 2 stitch to close the corner after introduction of the catheter into the bowel D Completion of the inversion E The resultant peritoneal tunnel Withdrawal of the catheter when enterostomy is made in thi manner is not followed by fistula

The Technique of Enterostomy

The site—Any distended loop of bowel proximal to the obstruction may be selected for the site of drainage On the whole, the nearer the site of the obstruction the more adequate will be the decompression The amount of gas as well as fluid drainage, however, is dependent largely upon the grade of the obstruction When, following decompression the nature of the obstruction is such that automatic re establishment of the continuity of the gut occurs as in most complete adhesive obstructions (even when no direct attack is made upon the obstructive agency), there



A



B

Fig 47—Operative decompression of distended small bowel to avoid spillage

A—Method of emptying a distended loop of small bowel preparatory to enterotomy It is well to aspirate with a needle following the application of clamps to make certain that the loop is empty

B—Alternate mode of emptying a distended loop of small intestine which can not be delivered and evacuated by the stripping process shown in Fig 47A The simple instrumentarium for this procedure should be available at every operation for acute intestinal obstruction

will be no considerable prolonged *escape of either gas or fluid These* are contingent upon the degree of obstruction and not upon the level in the gut, at which the decompression is made Still it is obvious that the nearer the enterotomy is to the site of obstruction the more complete will be the evacuation of the gut immediately above the obstruction, with consequent earlier restoration of its continuity Hence on the whole jejunostomies drain more freely than ileostomies but only because re establishment of intestinal continuity does not follow so readily

Tapping the bowel aseptically—The only manner in which one may safely place sutures in a very thin and distended bowel is by emptying it so that its muscle will contract and lend substance and thickness to the gut wall *By segregating a segment of gut between two clamp* first "milk ing out' some of its content by running this segment through the fingers and aspirating the remainder with a syringe complete evacuation is obtained A small catheter (No 14 French) may then be placed upon the collapsed bowel in its longitudinal axis and buried by a running suture of very fine silk or catgut The writer s preference is to employ interrupted sutures of fine silk placed after the Halsted plain quilt or mattress pattern After the suture has been partially completed (Fig 48), a puncture is made with a cataract knife and the proximal end of the catheter is threaded into the gut the interrupted silk sutures are continued for a short distance beyond, making a peritoneal tunnel in which the catheter lies (Fig 48) *After the catheter has served its purpose, as an emergency* outlet for the intestinal content granted that the normal avenue has again opened up as indicated by absence of escape of much gas and fluid through it, it may be removed by undoing its anchorage to the skin No fistula develops for the tiny peritoneal tunnel invariably closes spontaneously The writer has left the catheter for various reasons in the bowel for long periods of time—even after dismissal from the hospital When the catheter is withdrawn even after the lapse of weeks, there is no leakage

Methods of evacuating the gut by stripping at the time of the operation as advocated by Monks Moynihan Holden and Vandenberg are accompanied by considerable risk Laewen Morton Ochsner and Storck, and Sperling and Kremen have pointed out that stripping of the bowel in the presence of acute obstruction and great distension is fraught with hazard Yet if the emptying of the distended bowel by some such plan could be achieved with minimal manipulation of the bowel itself taking great pains to avoid spillage a method of extending helpful surgical aid to the late case will have been evolved *Introduction* of a moderately large tube to which suction is applied would appear to offer less trauma to the distended bowel than stripping and drawing the distended bowel over a Monks Moynihan evacuator (See Caption Q below and Fig 53) The precipitous fall in pressure and associated ill consequences are probably not so much the result of sudden decompression as insisted by Elman but rather the result of trauma to the gut wall Wangensteen and Scott have shown that the fall in pressure attending decompression of a distended abdomen may be averted in part by preliminary adminis-

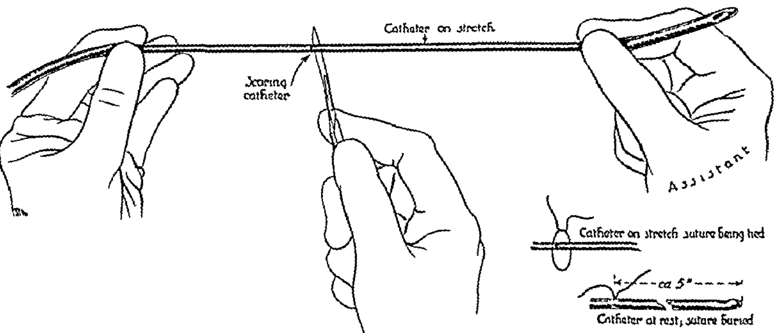


Fig 49 —Method of scoring catheter to fasten it in the bowel (Arch Surg 26·958 1933)

closed, and tie catheters into proximal and distal loops, than to do a primary resection The risk of making a primary anastomosis depends chiefly upon two factors (1) The enhanced risk of peritonitis even with aseptic forms of anastomosis because of the tremendous increase in number of bacteria in the obstructed bowel and (2) abnormal fragility or reduced

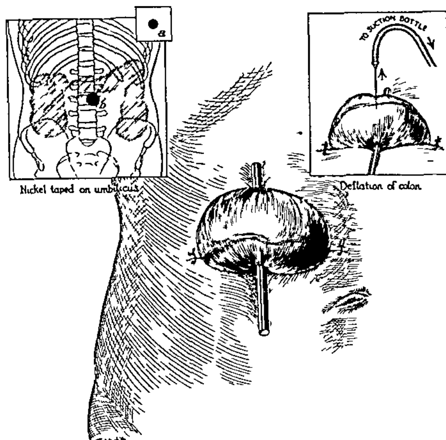


FIG 50 —Technique of decompressing the distended colon Sketch of a radiogram from a case A five cent piece is taped over the umbilicus In the insert on the left the actual size of the nickel drawn to scale is shown in *a* The 33% enlargement on the anterior abdominal wall is shown in *b* The intestinal coils within the abdomen are enlarged 25% In the insert on the right the method of deflating the colon on completion of the operation is shown After a few such aspirations the bowel is incised and a tube is inserted before it is finally cut across The tension in the bowel is determined before its contents are aspirated

strength of the obstructed bowel even proximal to the strangulated gut Where considerable gut is devitalized and especially where the fistula is high because of the impoverished alimentation and nutrition in consequence of loss of digestive juices, primary resection would be the lesser of the two evils In the more usual circumstance especially if the devitalized gut is in the lower ileum or colon much less risk is assumed for the

tration of pituitary extract, adrenalin, and other drugs which sustain the blood pressure, as well as *intravenous infusions* No such protective influence is provided by similar measures in the patient or animal whose gut is "stripped" The dog with obstruction of the small bowel tolerates "stripping" *particularly badly under ether anesthesia The same procedure* under pentobarbital sodium anesthesia is somewhat better tolerated (Sperling and Kremen)

H DEALING WITH THE OBSTRUCTED COLON WITH ENORMOUS DISTENSION

Whereas a malignant or inflammatory stricture in the pelvic colon constitutes a simple type of obstruction, the presence of the proximal ileocolic valve and sphincter may convert the colon into a closed loop obstruction The contents of the ileum are discharged into the cecum, but may not in turn be regurgitated back into the ileum With the elapse of time and consequent upon the increasing distension, secretion from the mucosa of the gut is increased, while absorption is retarded All the features of a strangulating obstruction may then become manifest in at least part of the gut, and usually in its most dilatable portion, viz, the cecum, where ulceration, gangrene, and perforation may be observed When such a bowel *wall* has gradually been subjected to obstruction, its *wall* may hypertrophy considerably Then when acute obstruction supervenes, the stress which would ordinarily cause rupture of a previously unobstructed *gut may be withstood*

The roentgen film indicates quite accurately the extent and length of the gut concerned in the distension As previously stated, the small bowel participates rarely in the distension Inasmuch as subsequent operations remain to be done upon the obstructing agent, the site of colostomy must be somewhat removed from later sites of entry into the abdomen The cecum, the usual site of decompression is not well suited for the performance of an aseptic tap, for it can rarely be delivered adequately to permit of segregating safely a segment upon which an aseptic decompression may be done When the cecum remains the only site for the establishment of an outlet for intestinal content it is best to insert the catheter through the appendix or the terminal ileum, and, in the latter instance, finally through the ileocecal valve, unless the cecum can be delivered adequately *Another alternative but less acceptable procedure* consists in circumscribing an area of the cecum with gauze and puncturing subsequently with a trochar

When the greater portion of the colon is concerned in the distension, it is decompressed usually best through a high short, transverse right rectus incision a glass rod being placed beneath the transverse colon This method permits of complete deviation of the fecal stream, an item of no mean importance for the subsequent operations (Fig 50)

I MANNER OF DEALING WITH STRANGULATED BOWEL

On the whole, it may appear to be safer in the presence of great distension, to exteriorize devitalized bowel, cut it off when the skin is

to be governed by the comparison and by experience, together with the other points that we have brought out The bowel wall at the point of resection when in the spastic stage should be nearly white in color showing that the capillaries are not thrombosed, since the blood is expressed from them by the force of the contraction In obstructed bowel where the circulation is damaged and there is beginning gangrene, even though the bowel will contract it remains rather dusky in color, probably due to thrombosed capillaries

Thirdly, we found that in suturing obstructed bowel the needle meets increasing resistance as one goes from badly damaged bowel wall toward that which is approximately normal and this is one of the tests that we use to determine a suitable point We feel that this is due to oedema of the submucosa since this layer is the layer that causes resistance to the passage of the needle In doing the anastomosis there is always, even at the point of resection, some difference between the resistance to the passage of the needle through the wall of the upper end of the lower segment This shows that even where anastomoses will hold and resection is safe this oedema still persists to some extent"

In performing resection with primary anastomosis for obstructive lesions in the small intestine non strangulating in character, the writer feels that the resistance encountered by the needle, in passing through the tissue is probably the most important determinant of a safe place at which to make the anastomosis In strangulating obstructions it is also an important guide However, in such instances, color changes and contractility of the gut are auxiliary aids For purposes of orienting the surgeon with reference to resistance encountered by the needle in making the suture it is probably wise to start the suture in the bowel distal to the obstruction

K EXTERIORIZATION WITH FISTULA

The only anxiety the surgeon need have with the employment of enterostomy relates to (1) whether the loss of secretions may prove serious and (2) whether the intestinal continuity may have to be restored by another operation The latter event is accepted for the patient without complaint by the surgeon when he relieves obstruction of the pelvic colon by colostomy In the small intestine, continuity is frequently automatically recovered without added operation and the loss of fluid through an enterostomy opening will only prove serious when the fistula is high and the obstruction complete High complete fistulas are to be deliberately avoided When excision of non viable gut becomes necessary in the upper half of the small intestine exteriorization of the devitalized gut is to be avoided whenever possible Connection of the two fistulous openings by means of a rubber tube and glass cannulas will temporarily help to avoid the disastrous results of a high fistula in those instances in which a primary anastomosis does not appear indicated until closure of the fistula can be made with less risk With employment of the closed method of anastomosis surgeons are abandoning exteriorization more and more in favor of primary resections

patient, with considerable intestinal distension, if a secondary anastomosis is made during the convalescence after initial exteriorization. If, however, the technical difficulties occasioned by distension do not loom large, primary resection, especially in the instance of obstruction of the small intestine is to be considered. Primary resection, wherever feasible, is becoming the policy and practice of this clinic. Employment of the closed anastomosis reduces, considerably apparently, the risks of the open anastomosis. This item will be dealt with at length, under the subsequent caption of primary resection.

J. DETERMINING WHETHER THE BOWEL IS VIABLE

The criteria upon which one decides the viability of the bowel are essentially (1) the color, (2) the absence or presence of pulsations in the mesenteric arteries along the border of the bowel, and (3) the contractility of the muscle of the bowel wall when pinched. The most reliable of these is color. Distinctly viable and devitalized bowel can be recognized readily. In border-line cases, it is difficult to be certain by any method. The temperature of the strangulated gut has been determined by use of a thermocouple and it has been advocated that a superficial incision be made to note whether the bowel wall bleeds—a hazardous procedure. Failure of return to normal color and lustre of the bowel wall indicates that the blood flow has been seriously compromised. Persistence of a dusky color and engorgement of the mesenteric veins suggest that the bowel should be treated as though it were not viable. In doubtful instances, it may be exteriorized without opening it; if the color improves, the bowel may be returned to the peritoneal cavity.

With reference to determining the safe point for resection in obstruction, Owings and Smith (1932), who have given the matter special study, have the following to say: "The more experiments we did the harder we felt this point was to determine with any degree of exactness. We felt that the best things to judge by were first, the ability of the bowel to contract when mechanically stimulated, that is, not only ability to contract but to contract completely: go into actual spasm. This spasm is readily induced by tapping the bowel with a clamp or pinching it or plucking it with the finger. It is important to notice whether this bowel at the height of its contraction comes down to the size that one would expect normal bowel to reach under similar stimulation, because this helps to determine the degree of oedema which is the best expression of the early reaction of the bowel to obstruction.

Secondly, the circulation of the bowel wall and the mesentery is very important. There should not be any oedema of the mesentery, and pulsations should be clearly seen and felt in the mesenteric vessels. The circulation in the bowel wall itself is best determined by its color during both spasm and relaxation. During relaxation a point should be picked where the color of the bowel wall changes from the dusky, non glistening color of damaged circulation to a point as near the normal pinkish glistening color as possible. This point is very hard to determine as the change is a very gradual one and the normal color is never actually reached. One has

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DIETARY MANAGEMENT IN HIGH INTESTINAL FISTULA

An adequate nutrition can not, of course, be maintained over any great length of time without the greater portion of the small intestine being intact this is particularly true of infants and children The baneful systemic effects of the profuse loss of vital fluids through a high intestinal fistula may be largely set aside over a short period of time by the liberal para oral administration of saline solution, and in part as well by the collection and return of the fluid drainage by proctoclysis or preferably through the distal fistulous opening



Fig 51 —Manner of dealing with an intestinal fistula when exteriorization is done for gangrenous small bowel The fluid that drains away from the proximal loop is collected and is run into the catheter in the distal loop by the drip method Primary closed resection has done away largely with need for exteriorization in mid small intestine (See Fig 142 also) (Arch Surg 26 959 1933)

After the establishment of a complete fistula of the small intestine careful dietetic management is highly important In a few instances of this sort, the writer has had the helpful co operation and assistance of Professor Irvine McQuarrie and his associates of the Pediatric Department of the University of Minnesota in providing a suitable diet for such patients Fat apparently enhances the motility of the gut and decreases the time over which an abnormally short gut surface must absorb the digested food A high carbohydrate and protein diet seem to be most readily assimulated, and less food appears in an undigested state at the fistulous opening The absorption of proteins which are assimilated readily appears to be an important item in preserving a normal water and salt balance Despite the liberal administration of intravenous saline solution to such a patient, the tissues do not seem able to hold water until protein is being absorbed from the gut Milk skim milk, lactose cheese, eggs cooked cereal ground liver, candy, yeast cod liver oil and orange juice have furnished the basis for a satisfactory diet in instances of high ileal fistula The caloric value of the food served and that not eaten should be carefully estimated and recorded A daily caloric intake of about 2000 to 2200 calories can be provided with such a diet giving 250 to 275 grams of carbohydrate, 90 to 100 grams of protein, and 70 to 80 grams of fat A formula containing a mixture of glucose, milk, eggs peptone and yeast constitutes a satisfactory preparation to run into the distal fistulous opening by the drip method to augment the oral intake of food If need be caloric and nitrogen balance can be maintained by intravenous feeding (see page 245)

The formula of Scott and Ivy, which the writer has had occasion to

employ on many occasions, contains the following proportion of ingredients

TABLE XXII.—INGREDIENTS OF THE SCOTT IVY FORMULA FOR JEJUNAL ALIMENTATION

Water	300 cubic centimeters
Cane sugar	15 grams
Peptone (dried)	10 "
Wheat flour	30 "
Milk (whole)	200 cubic centimeters
Cream (20 per cent)	100 "

One hundred cubic centimeters of this *formula contains approximately* 80 calories However, when entering the intestine at a low

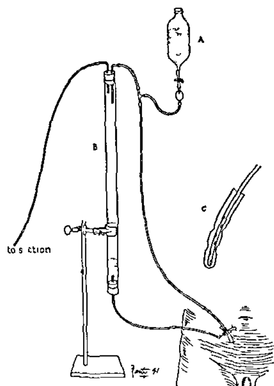


FIG 52.—MacNaughton's scheme for carrying away intestinal secretions from an intestinal fistula Fluid is allowed to run under the influence of gravity from the drip bottle (A) The use of a Sprengel water pump creates a negative pressure in (B) the subatmospheric pressure causes the fluid escaping from A to be drawn over into B with the establishment of a siphonage force in the fistula A perforated glass tube (C) surrounds the catheter in the fistula (MacNaughton Surgery 9 372 1941)

level, its food value because of the imperfect digestion, is considerably less *If diarrhea attends the drip feeding of this formula the amount of* fat is to be decreased In addition, a sufficient quantity of saline solution should be given by vein or by proctoclysis to insure a satisfactory urine output When the patient's condition permits the fistula should be closed The dietary regulations here outlined have proved helpful in enabling the patient with a high intestinal fistula to gain weight when his status could not be satisfactorily maintained on an ordinary regimen

Kirschner's jejunostomy feeding mixture has been used in this clinic

with some satisfaction The ingredients are indicated in the accompanying table

TABLE XXIII—KIRSCHNER JEJUNOSTOMY FEEDING MIXTURE

1750 cc whole milk	1225 calories (100 cc = 70 calories)
50 g barley meal	200 calories (100 g = 400 calories)
50 g glucose	200 calories (100 g = 400 calories)
200 cc cream	400 calories (100 cc = 200 calories)
5 g table salt	
Total Volume 2055 c c	2025 calories
Approximately 1 calorie per cc	

The experience of this clinic suggests that the ideal formula for feeding through an enterostomy has not been found Trial and error, with temporary periods of alimentation by the intravenous route, until the proper adjustment is made, continues to be the method that must be applied in a number of instances The Walters and Hartman formula, employing an ice cream base has been used with satisfaction in a number of instances Our experience with it suggests that the fat content should not be increased beyond that suggested by Walters for the third day feeding The formula appears in the accompanying Table

TABLE XXIV—WALTERS HARTMAN JEJUNOSTOMY FEEDING FORMULA

	Day on Which Diet is Employed		
	1st	2nd	3rd
Total cc per hour	30	30	60
Total cc per day	720	720	1 440
Ingredients			
Ice cream mix Gm	150	200	400
Skim milk powder Gm		25	50
Eggs			1
Dextrose Gm	25	25	60
Ascorbic acid mg			25
Halibut liver oil drops			15
Thiamin chloride mg			3
Water cc	570	520	990
Composition			
Carbohydrate	47	65	139
Protein	6	15	36
Fat	21	30	66
Calories	401	590	1,294

Walters and Hartman have the following to say concerning the preparation of their formula Ice cream mix as used in making ice creams in most institutions is a combination of whole milk powder ice cream or butter fat egg powder and gelatin (carbohydrate 15 Gm protein 4 Gm fat 14 Gm) The mix is homogenized and has been more successfully used in making the formula than the milk and cream mixture formerly employed More normal stools result in cases in which it has been used Method of preparation *Mix skim milk powder with water to make a smooth paste* Add the remainder of the water specified for that particular formula dextrose and ice cream mix Beat the eggs add halibut liver oil and beat again Combine these mixtures strain and add dissolved ascorbic acid and thiamin chloride Individual feedings should be warmed to body temperature in hot water before administering

M PROTECTION OF SKIN

For protection of the skin in the presence of a fistula when the drainage is profuse and the fluid can not conveniently be collected through a catheter, employment of a Sprengel water type of suction apparatus is found particularly useful MacNaughton has described, recently, a simple but effective device to obviate spillage from an intestinal fistula, onto the skin (Fig 52) Covering the skin adjacent to the fistula with yeast, as described by Mead, is a simple and one of the most effectual means of preventing excoriation of the skin A yeast cake is made up into a batter with water and is applied over the skin Its chief drawback is that when the yeast dries, it cracks and has to be removed, necessitating rather frequent applications of fresh yeast batter A five per cent tannic acid ointment has been found to be very effectual Another useful expedient is an ointment of 25 per cent metallic aluminum with a vaseline base

N ENTERO ANASTOMOSIS

The indications for the performance of entero anastomosis are not easy to define In the main it is the writer's impression that entero anastomosis has rather limited indications in the presence of acute intestinal obstruction with great distension Entero anastomosis is to be reserved for those acute obstructions in which enterostomy, exteriorization with the establishment of a temporary complete fistula, or primary resection will not do The performance of an entero anastomosis assumes that the bowel is viable and that the obstruction itself is irremovable or that its removal should be left to a more opportune time There are, however, occasions when no other procedure seems to meet the situation as well In a recent instance of displacement of the upper jejunum beneath a gastrojejunal anastomosis occurring several months after gastric resection for ulcer causing acute obstruction no other operation appeared to satisfy the requirements of the situation After deflation of the distended loop by needle aspiration (Fig 47b), 750 cc of yellowish stercoraceous fluid being removed, entero anastomosis by the closed method was made easily with recovery of the patient

Morton (1932, 1937) has had considerable experience with entero anastomosis in certain types of obstruction, and is probably one of its strongest advocates The writer believes that the chief place for entero anastomosis lies in the special indication as cited above, or in the less acute or chronic varieties, as exemplified by obstruction of the bowel by tumor Yet even here if entero anastomosis can be performed with safety, excision with primary resection should be the preferable procedure There remains however the case in which an entangled mass of adhesions constitutes the obstructive mechanism Enterostomy in such cases, in the opinion of the writer, is the operation of choice Yet there are circumstances which suggest that entero anastomosis is occasionally the procedure of choice Any anastomosis in the presence of obstruction should be made by the closed technique

It is not to be forgotten, however that there are certain remote risks

which attend employment of entero anastomosis Estes and Holm and Pearse have warned that distension and obstruction may occur in side tracked loops As a matter of fact, resection by exclusion is an old principle in the management of carcinoma of the colon Its use has been described successfully by V Hacker, Salzer and others When the short circuited loop is not long and the obstruction for which the entero anastomosis is done is incomplete, the remote hazards described by Estes and Holm, and Pearse are *probably of no great importance For a patient* presenting an anemia of obscure origin, the writer excised such an entero anastomosis, which had been made 18 years before An ulcer was found in the loop distal to the anastomosis The anemia was cured and the patient *has* remained *well for* more than 6 years

The performance of entero anastomosis between the small intestine and the colon, on the indications suggested by Sampson Handley in so called ileus duplex" is ill advised

O ATTACKING THE OBSTRUCTIVE MECHANISM DIRECTLY IN SIMPLE OBSTRUCTIONS

Enterostomy is, at best, a compromise procedure Often, however, the surest way of attaining an objective is through the indirect measure of compromise Under the section of Enterostomy, some of the hazards, that confront the surgeon who elects to attack the obstructive agency directly, are described The writer speaks from bitter lessons learned from personal experience It is the case of simple obstruction, presenting an entangled mass of adhesions, that the writer would caution the surgeon from attacking directly, in the presence of great distension The single adhesive band is *a different matter* It may be divided usually with safety However, it is to be remembered, after several days of occlusion, that adhesive band and gut wall may be fused into one Traction or manipulation of the adhesive band may open the bowel with consequent spillage—an occurrence *which seals the doom of the patient almost invariably*, because of the presence of high bacterial counts in obstructed intestinal content

When, however, the obstruction concerns a gall stone or other impacted solid body, it must be removed usually The technique for the removal of an obstructing gallstone, depicted on page *320* has proved *very satisfactory* It permits removal of the stone without contamination The management of a tumor of the bowel is discussed under the caption of Primary Resection The suggestions outlined under methods, of dealing with distension at operation to reduce the risk of primary resection in gangrenous obstructions, apply equally well here He who essays to deal directly with obstruction, must be in a position to deal effectually with the problem of distension, if need be

P RESECTION WITH PRIMARY ANASTOMOSIS

[illegible]ke entero anastomosis, primary resection has definite indications [illegible] obstructions, in the upper jejunum when the bowel viability primary resection is in order In all extensive *proc-* the bowel has lost its viability, as typified by mesenteric

thrombosis or volvulus of the small intestine, excision and primary anastomosis are indicated The establishment of an external fistula in such instances *must not be done* In gangrenous processes of lesser length situated in the upper jejunum primary resection is likewise the operation of choice When such gangrenous processes involve the lower ileum, the general tendency, in the main, has been to favor exteriorization, on the principle that it is the procedure of lesser risk, and that fistula is well tolerated at this level, even in infants In strangulated hernias, intussusception with non-viable bowel, volvulus and devitalized bowel occasioned by adhesive mechanisms, it is becoming more and more the practice of this clinic to do primary resections My associate Dr Clarence Dennis, together with senior surgical house officers in this clinic, has during the past year, done 8 consecutive primary resections for non viable strangulations of the small intestine with no mortality One of these included an infant of two months with an irreducible gangrenous intussusception, for which a primary end to end anastomosis of the ileum was made In gangrenous processes in the colon, however, in the presence of distension the exteriorization principle is still the operative procedure of choice Under the section on Volvulus, it is pointed out that Muschkatin (1932) advises a primary extraperitoneal end to end anastomosis after resection of non viable segments of torsioned pelvic colon Koster (1940) has advised recently, such extraperitoneal placement of the anastomosed segments of the colon, following primary resection of unobstructed lesions Such a practice indicates little confidence on the part of the surgeon, to make a satisfactory anastomosis

In the presence of a tumor of the small bowel causing acute intestinal obstruction, the indication for primary resection is not so compelling If distension does not loom as too formidable a problem, primary resection, employing the closed anastomosis would be the first choice of operative procedure in this clinic Alternative schemes which could be employed are 1) entero anastomosis 2) exteriorization and 3) enterostomy for the relief of acute obstruction

If excision of the lesion *per se* presents no great problem, primary resection with end to end anastomosis may be done with about the same risk as entero anastomosis In the presence of great distension, enterostomy or exteriorization with temporary fistula formation would have to be given consideration

Q ADDITIONAL METHODS OF DEALING WITH DISTENSION AT OPERATION TO REDUCE THE RISKS OF PRIMARY RESECTION

This writer has pointed out, on every occasion on which he has expressed himself on the bowel obstruction problem, that an enterostomy, when properly done, is a good and *safe* operation It is obvious that neither needles nor sutures can be passed with impunity through a distended paper thin bowel wall A leak will occur at every puncture If however the content of a segment of the bowel is evacuated by the milking process and the segment is segregated between clamps and the remainder of the content of the loop emptied by needle aspiration (see Figure 47), catheter

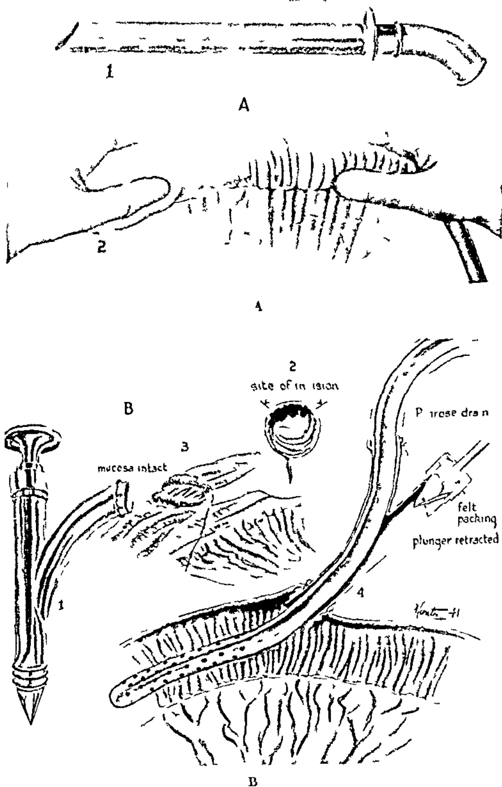


Fig 53 (See page 209 for explanation)

enterostomy can be done with safety Within the space of a few seconds, the paper thin bowel wall acquires substance, permitting placement of sutures

If primary resection is contemplated, in the presence of a satisfactory indication, it is obvious that the distension in the proximal obstructed segments of bowel must be dealt with In some instances, the method employed in enterostomy will suffice In others, multiple needle aspiration carried out on the same plan may do A distinct advantage in eliminating the perplexing item of distension from long segments of bowel, is that better orientation may be reached concerning the exact nature of the obstructing mechanism—an item of great importance, in instances when so formidable a procedure as primary resection is contemplated

Extension of use of the method suggested by Monks and endorsed by Moynihan and Holden suggests itself as a possibility for emptying the distended bowel The potential source for contamination—a dangerous accident, is apparent Further, Laewen, (1927) Morton, (1932) Ochsner and Storck (1936) and Sperling and Kremen (1939) have pointed out, that stripping of the bowel in the presence of acute obstruction and great distension, is fraught with hazard Yet, if the emptying of the distended bowel by some such plan could be achieved with minimal manipulation of the bowel itself taking great pains to avoid spillage a method of extending helpful surgical aid to the late case will have been evolved

Aseptic Decompressive Suction Enterostomy

There are occasional instances, when it becomes mandatory to deal effectually with the factor of distension, at operation Instances in point are (1) occlusion of the bowel by an adhesive band, deep in the pelvis which can not be exposed for visualization because of the existing dis

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Fig 53 Operative methods of achieving decompression of the distended small intestine

A The Monks Moynihan procedure In (1) is shown the tube (2) indicates the method of stripping the distended bowel and reefing it on the tube

In this method the fluid content of the distended bowel escapes by siphonage

B The writer s plan of aseptic decompressive enterotomy A loop of distended small bowel is emptied and segregated between clamps as indicated in Fig 47A (or as in 47B) (1) The instrument constructed on the general plan of an empyema trochar (2) The site of the transverse incision (3) Placement of a fine catgut pur e string suture the incision extends to the mucosa (4) A long urethral tipped tube with multiple small perforations is introduced through the ide arm of the enterot omy Penrose tubing longer than the rubber tube is fastened to the side arm of the trochar at one end and to the proximal end of the rubber tubing at the other Glycerine is placed within the Penro e drain tubing before it is drawn over the suction tube—this maneuver permits the suction tube to be advanced or withdrawn with relative ease The purpose of the Penro e tubing is to prevent soiling of the operator s hands by the suction tube when the latter is withdrawn from the bowel

With a Y glass tube connected to the rubber tube and a ource of active suction a non sterile assistant may make and break the suction force Decompression suffi cient to permit evacuation of the contents of several distended intestinal loops may be accompli hed by this agency with less hazard of pillage and with far less trauma to the intestine than with stripping of the bowel in the u e of the Monks Moynihan tube

tension. Enterostomy is an alternative procedure in some such cases. Yet, drainage of the intestinal canal alone, without removal of the obstructing band, leaves a great deal to chance. The writer has observed penetration of the bowel wall, by the constricting band, with ensuant peritonitis, when such an obstruction was treated by enterostomy alone; (2) obstruction occasioned by a tumor or other obstructive mechanism which might be removed with reestablishment of intestinal continuity by primary resection. This latter indication, under ordinary circumstances, represents, often, only an extension of the principle of primary resection; however, it, too, like the first indication (occlusive adhesive band), may become a matter of necessity, constituting the safest and most effective manner of dealing with the obstructing agency.

The objection to use of the Monks-Moynihan principle of intestinal evacuation is that, the maneuver of stripping damages the bowel and threatens the life of the patient (Fig. 53A). The writer conceives of dealing with the item of distension, in those instances in which operative decompression is necessary to visualization of the site of obstruction and its management, in the manner depicted in Fig. 53B. Employing an enterotomy evacuation cannula, resembling in principle an empyema trochar, operative decompression may be achieved by advancing a long, moderately stiff rubber tube into the bowel lumen. (Sizes 20, 24, and 30 French have been used.) In the placing of the cannula, the care observed in the making of an ordinary enterostomy must be taken, to avoid spillage (Figs. 47 and 48). The catheter with many small perforations like the Kenyon-Pool metal abdominal suction tube is advanced slowly into the distended gut. In this maneuver, *suction can be employed* to deal with the distension rather than the manipulative procedure of the Monks-Moynihan method of intestinal evacuation. A distended loop in the vicinity of the obstruction should be chosen for evacuation. Monks devised intestinal evacuation to wash out toxic material from the distended bowel. The writer employs the procedure outlined here, which may be described as aseptic decompressive suction enterotomy, to reduce distension in suitable instances, such that the surgeon may see and deal, intelligently and effectually, with the obstructing agency. All the distended intestine need not be decompressed, therefore, as a prelude to dealing with the obstruction itself.

Some reefing of the bowel upon the catheter is necessary in accomplishing decompression by the method described here. However, such manipulation does not concern the distended bowel. Only after a distended loop has been emptied by suction need it be drawn over the catheter to permit decompression of more proximal reaches of distended intestinal coils. Pressure upon gaseous distended coils of bowel will facilitate decompression, and gentle elevation of coils distended with fluid will aid in bringing the contents of the distended segment within reach of the aspirating tube. The catheter may be withdrawn from the bowel and advanced in the other direction if desired. The Penrose tube drain (see Caption Fig. 53B) overlying the aspirating catheter precludes contamination of the surgeon's hands on withdrawal of the tube. The glycerine within the Penrose drain facilitates manipulation of the aspirating catheter.

Enterostomy will continue to have a wider field of usefulness than aseptic decompressive suction enterotomy Yet, this latter procedure will enhance the ability of the surgeon to deal with certain obstructions, presenting great distension, more effectually and with greater safety to the patient It is the practice of this clinic to implant 2 to 4 grams of sulfathiazole about openings or anastomoses made in the bowel

The scheme of operative decompression depicted in Fig 53B and described here has been used successfully and with satisfaction at operation upon a patient with an obstruction of seven days' duration, in whom an adhesive band, deep in the pelvis, occluded the bowel completely After aspiration of the intestinal loop involved, the band could be visualized and cut It was fused intimately with the bowel wall After severance of the band, the gut appeared to be intact Gentle manipulation demonstrated that the band had cut deeply into the bowel, the lumen being entirely open, over three fourths of the circumference of the bowel Only at the mesenteric attachment was the gut wall intact The bowel having been sucked out there was no spillage and the patient recovered Performance of "blind enterostomy" in such a patient would, in all probability have been doomed to failure from the start

B PARTIAL ENTERECTOMY IN AN UNOBSTRUCTED INTERVAL FOR RECURRENT OBSTRUCTION DUE TO ADHESIONS

An operative procedure which has come to be performed more frequently in this clinic, is partial enterectomy for recurrent obstruction due to entangled masses of adhesions Since the first edition of this book was published in 1937 a fairly large number of recurrent obstructions have been operated upon, on this plan Previously, enterolysis, as described under the Chapter on Adhesions, was done largely Partial enterectomy, with sacrifice of that part of the bowel involved in the snarl of adhesions, has proved to be a far superior operation Mere lysis of the gut in such instances is followed too frequently by recurrence of the obstruction An aseptic oblique end to end anastomosis, in practiced hands carries minimal risk and presents the distinct advantage of getting rid of the focus, which continues to foment obstruction

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Chapter VIII

THE CLOSED ASEPTIC RESECTION

The closed anastomosis, though by no means new, has been slow to acquire momentum In colonic resections, the method has had isolated proponents and adherents but, in the main, the open anastomosis has continued to be the anastomotic procedure practiced most widely Halsted and his pupils experimented for years with technical maneuvers to facilitate performance of the closed anastomosis And though Halsted, in his lifetime, did not succeed in developing an aseptic method of anastomosis, wholly to his liking, he stimulated a good deal of interest in the subject and his teachings have had a profound influence on modern practice

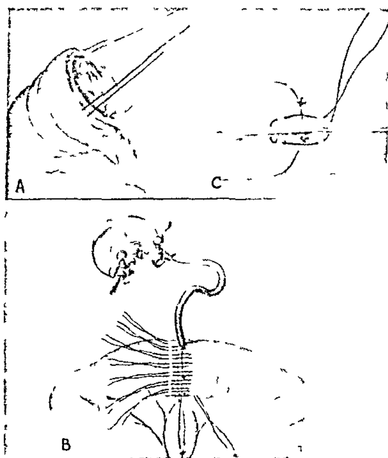


Fig 54 —Techniques suggested by Halsted in the making of an end to-end anastomosis A Placement of presection sutures to avoid eversion of mucosa B Inflation of a small cylindrical balloon to facilitate placement of sutures in end to-end anastomosis C Mode of dealing with the mesenteric angle—the so-called Mitchell Hunner stitch (Collected papers The Johns Hopkins Press)

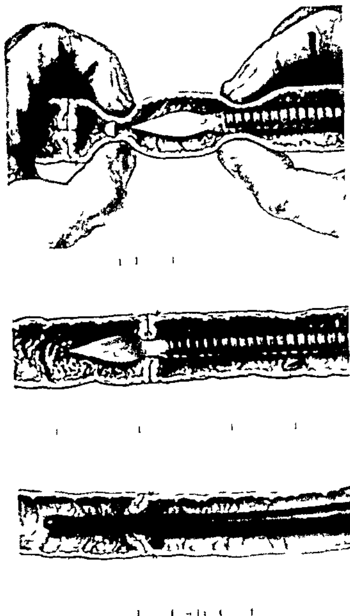


Fig 55—Method suggested by Halsted to accomplish primary resection and anastomosis by the closed method in the pelvic colon (Collected papers The Johns Hopkins Press)

At one time he employed an inflatable rubber balloon with which to establish continuity in the small intestine after resection (Fig 54) One of his last papers dealt with a means of establishing a closed anastomosis in the pelvic colon, after resection (Fig 55)

The basting stitch, advocated by Parker and Kerr (1908), was the first

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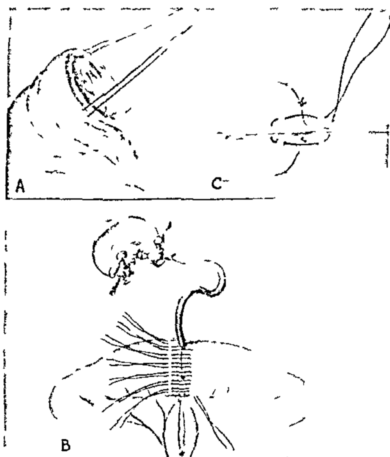


Fig 54 —Techniques suggested by Halsted in the making of an end to-end anastomosis A Placement of presection sutures to avoid eversion of mucosa B Inflation of a small cylindrical balloon to facilitate placement of sutures in end to-end anastomosis C Mode of dealing with the mesenteric angle—the so called Mitchell Hunner stitch (Collected papers The Johns Hopkins Press)

colectomy for multiple neoplasms, in which the greater portion of the colon, save the cecum and a portion of the ascending colon, are sacrificed, an end to side union between the end of the pelvic colon and the cecum constitutes the simplest method of re establishing intestinal continuity Side to side anastomoses are reserved for the occasional entero anastomosis necessary after gastric resection, and as a side tracking operation in intestinal obstructions, presenting a suitable indication Gastrojejunostomy is of course, a side to side anastomosis, but it is performed today in most clinics far less frequently than 5 years ago

All of these anastomoses may be made by the closed (aseptic) method As was pointed out above, however, wherever feasible, the oblique end to end anastomosis, in intestinal resections is carried out, as the procedure of choice

A TECHNIQUE OF OBLIQUE END TO END ANASTOMOSIS

Making an oblique anastomosis has two distinct advantages 1) It permits sacrifice of a greater length of the antimesenteric border of the intestine, insuring, therefore the best possible vascularization of the anastomosed segments, 2) It affords an excellent opportunity to increase the length of the stoma, in segments of bowel where the diameter is small

The technical steps in the making of the anastomosis are indicated in the accompanying sketches (Fig 57) The technique of all the anasto moses, whether end to end end to side or side to side, is essentially the same In the lateral anastomosis, the cuff of bowel above the clamp need not be cut away, until the posterior portion of the anastomosis has been completed The clamps which may be employed for any type of closed anastomosis are shown in Fig 60 The technique described here was evolved in establishing an end to side anastomosis after gastric resection The attachment of the mesenteries of the stomach made it mandatory to *complete* the posterior portion of the anastomosis before placement of any of the anterior sutures Yet, as the accompanying diagrams suggest this method constitutes a practical and satisfactory manner of making intes tinal anastomoses as well

Briefly, the anastomosis consists in placing a row of interrupted sutures of fine silk (2 pound strength test) in accordance with the plain quilt Halsted mattress pattern In the placement of these sutures one of 2 plans may be used All the sutures may be placed and tied only after all the sutures have been taken or 3 or 4 guide sutures may be placed, one at either end and 1 or 2 between The latter scheme affords opportunity to put gentle traction on the sutures and results therefore usually in the placement of a few more sutures than if all the sutures are placed before any are tied Anyone who employs these 2 schemes will soon instruct himself in the variability of the state of stretch or contraction of the bowel wall

The writer aims to place the interrupted silk sutures about 2 milli meters apart embracing slightly less than this distance in the grasp of the mattress stitch Fine curved needles, already threaded, and suitable small needle holders are employed routinely (Fig 44) When the sutures

technical procedure, in the execution of a closed anastomosis, that acquired any vogue amongst American surgeons A number of surgeons continue to establish intestinal continuity by this method The development of special clamps by Rankin, Martzloff, and Stone lent increased impetus and interest in the closed method of effecting intestinal continuity, after resection of a segment of intestine In 1940, the writer suggested that all anastomoses, in the gastro intestinal canal, including gastrojejunal as well



Fig 56—A scheme devised to circumvent the difficulty of the mesenteric angle in end to-end anastomosis of the small bowel (Redrawn from Horsley and Bigger Operative Surgery Volume II p 1070 5th Edition C V Mosby Company 1940)

as esophagojejunal after total gastrectomy, could be made by the closed method Over a period now of about 4 years in length all anastomoses in the alimentary canal have been made by employing the closed method in this clinic Gastric resection by the closed method has proved eminently practical In this clinic, the closed aseptic anastomosis has come to displace the exteriorization operation of Bloch, Paul and Mikulicz, in treating malignancies of the colon Preliminary colostomy is made only in obstructed cases and complemental enterostomy or colostomy has been done away with largely

The standard method of establishing intestinal union has come to be oblique end to end anastomosis, whether the resection is made in the small or large intestine After resection of the right colon, intestinal union is re-established by an oblique closed anastomosis between ileum and transverse colon Primary resection with oblique end to end anastomosis is made for lesions of the transverse colon, as well as the pelvic colon End to side, or side to side anastomoses, all of which may be made by the same technique are reserved for the unusual case Esophago jejunostomy after total gastrectomy and the gastrojejunal union after gastric resection by choice are made as end to side anastomoses After primary subtotal

in the posterior row have been placed, all the sutures are cut 2 millimeters above the knot The second row, posteriorly, the suture nearest the clamp, is usually a running suture of fine catgut (000) The interrupted Cushing mattress suture of silk is also a satisfactory stitch for this layer The



FIG 58—Solution of the difficulty of the mesenteric angle A Placement of the clamp upon the bowel wall at an acute angle (about 45) The external row of sutures will come within the confines of the dotted line—that is the first posterior row and the last anterior row will not be more than 75 of a centimeter (preferably 5 cm) away from the clamp B Detachment of the mesentery to a point 75 cm beyond the site of application of the clamp in an oblique end to-end anastomosis permits placement of every suture in the bowel wall The mesentery is not employed in the anastomosis The manner of dealing with the enteric angle shown here concerns the small intestine the same technique is employed in resections of the colon The preparation of the colon for the anastomosis (Fig 59) is a little more difficult

anterior rows are then placed in the reverse order first the suture nearest the clamp and finally the outer row of interrupted Halsted mattress

ant holds the bowel under tension while the surgeon places the first few guy sutures To one unaccustomed to the capacity of the small intestine to accommodate itself to varying states of contraction this stretch of the bowel under gentle pull may seem extraordinary B Three guide sutures of fine silk put after the Halsted mattress pattern have been placed in accordance with the plan suggested in A These 3 sutures are tied and enough additional sutures are placed to make a satisfactory approximation The sutures are placed a little less than 2 millimeters apart and the grasp of the tissue within the mattress suture is slightly less in width than the spacing of the sutures C The inner posterior row of running 000 catgut D The single ferrule have been removed the clamps have been rotated and the anterior inner row of running catgut has been placed The straight mosquito clamps identify the ends of the posterior catgut suture and the curved mosquito clamps are attached to the anterior suture E Technique of detaching the ferrule A tissue forceps is engaged behind it and a few taps from a hammer dislodges the ferrule F The completed anastomosis after placement of the outer anterior row of Halsted mattress sutures of fine silk

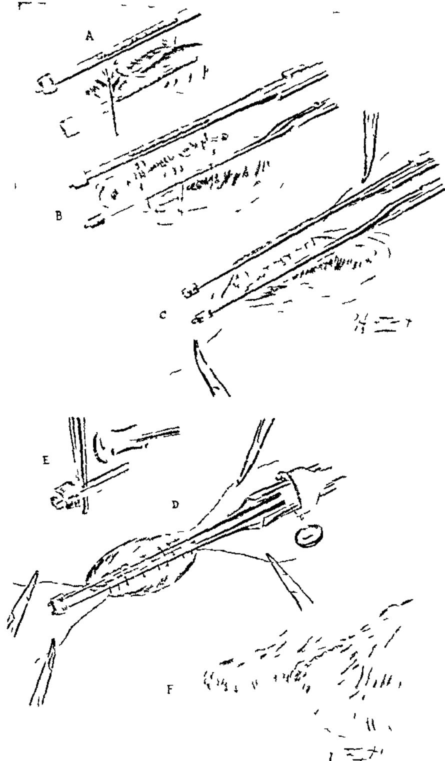


FIG 57—Aseptic (closed) oblique end to-end anastomosis in the small intestine A Beginning the first posterior row In order to avoid turning in a wide cuff the assist

sutures The manipulation of the clamps is described in the caption of Fig 57

The Halsted stitch effects a nicely everted border and results in maximal approximation of peritoneal surfaces All sutures in the closed anastomosis are placed, of course, from the peritoneal side of the bowel, and the caution urged by Halsted to place each suture into the submucous coat of the bowel must be observed The writer came to employ catgut for the inner row, when after gastric resection an occasional suture was observed, now and then on gastroscopic examination, dangling from the suture line If Halsted s teaching on this point is correct, such sutures must have penetrated the mucosa at the time of operation For, Halsted holds that sutures will penetrate toward the mucosa only if the surgeon entered the mucous layer with his needle

B MANAGEMENT OF THE MESENTERIC BORDER

In the end to end anastomosis, management of the mesenteric border has been always a special problem Halsted employed the scheme shown in Fig 54 This purse string type of suture, directed at effecting adequate closure at the mesenteric border, Halsted called the Mitchell Hunner stitch Horsley and Bigger depict the scheme of rotating the bowel employed commonly to lessen the problem of safe closure at the mesenteric angle in end to end anastomosis (Fig 56) However if the anastomosis is made *obliquely*, no matter whether in the small intestine or the colon, it is quite safe, and the writer s routine practice, to detach the mesentery three fourths of a centimeter (¾) beyond the site of section of the bowel The angle of division of the bowel is usually 45° or le s Such mesenteric detachment makes it possible to employ the same scheme of closing the mesenteric angle as in the rest of the bowel Unless the mesentery is detached beyond the site of section of the bowel it is not feasible to provide satisfactory closure at this troublesome point Mesenteric detachment as described above and illustrated in Fig 58 does away with this problem wholly Every suture should be placed in the gut wall The mesentery *must* not be relied upon to close the intestinal defect

C DEALING WITH THE EPIPLOIC APPENDAGES IN COLONIC ANASTOMOSES

A number of studies have shown that the fatty tags on the exterior of the colon play a role in the transport of blood to and from the bowel wall, that is these colonic appendages have vascular connections with the bowel wall Nevertheless the writer has come to deal with them as with the mesentery of the bowel (Fig 59) No suture of the colon can be regarded as safe unless the surgeon knows that every suture has been placed in the bowel wall itself Grasping a fatty epiploic appendage overlying the bowel wall, in a suture, is not an acceptable substitute for careful placement of each stitch into the proper layer of the bowel Here, as at the mesenteric border the writer lays bare the true peritoneal surface of the colon for three fourths of a centimeter (¾) beyond the proposed site of section of the bowel



FIG 59—Mode of preparing the colon at operation for an oblique end to-end anastomosis A The dotted line indicates the proposed site for application of the clamp B The fatty tags are underrun with a dis ector Each fatty tag is divided and tied as indicated to obviate hematoma formation The bowel wall is to be cleared for a distance of ¾ of a centimeter beyond the proposed site of section This maneuver permits the surgeon to place each suture directly in the bowel wall

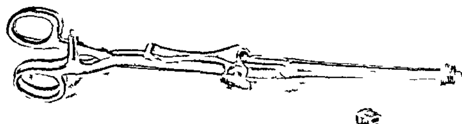


FIG 60—Resection clamps for the closed anastomosis The sketch shows the two clamps approximated with the double ferrule and the holding device over the shank Each clamp has a single ferrule as well These clamps patterned after the Martzloff instrument are adaptable for resections in small or large intestine as well as for gastric resections including total gastrectomy (Made by V C Mueller & Co Chicago)

Inversion of one half to three fourths of a centimeter (½ to ¾) of the adjacent edges of the walls of the colon affords satisfactory approximation The area of inversion should be only broad enough to insure satisfactory healing Inversion of more tissue results in narrowing at the site of suture and flap formation as shown in Figs 65 and 66 The writer has not observed compromise of the blood supply of the colon by removing all fat, including fatty epiploic appendages three-fourths of a centimeter (¾) beyond the point of section of the bowel, in *oblique* end to end anastomoses

D OBSTRUCTION AT GASTRO-JEJUNAL STOMAS

A troublesome complication of anastomotic procedures accompanying gastric operations, whether gastrojejunostomy or gastric resections, has been obstruction at the stoma and usually at the efferent outlet Whereas a number of causes have been alleged to implement the occurrence of this complication, such as the length of the afferent loop, the direction of the anastomosis, whether iso or antiperistaltic, and the site of the anastomosis upon the stomach, the likelihood is that of obstruction at the efferent outlet is brought about largely by oversuturing That is, the inversion of too great a width of the adjacent edges of the gastric and jejunal walls gives rise to flap formation, with the result shown in Fig 66 It is not likely that hypoproteinemia plays an important role in its genesis, ordinarily Chauncey (1939) failed to observe any direct correlation between the plasma protein values and the occurrence of stomal obstruction after gastrojejunal anastomoses Since observing the rule of not inverting more than three-fourths of a centimeter (¾) of the adjacent walls of jejunum and stomach no instances of obstruction at the efferent outlet after gastro jejunal anastomoses have been observed in this clinic, in more than 150 consecutive such anastomoses

As Fig 66 indicates, obstruction at the afferent inlet in gastrojejunal anastomoses is not likely to occur through the agency of over inversion for, the flap thus created does not obstruct the stoma of the inlet, as does a similar flap at the gastric outlet Angulation of the bowel is the most likely cause that may bring this situation about The transverse mesocolon should be anchored to the stomach above the line of the anastomosis

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sutures are placed as indicated and then tied One or 2 sutures are then placed between the guy sutures This the outside row of sutures should not lie at a greater distance than ¾ of a centimeter from the clamp B The inner posterior row a running suture of 000 catgut Interrupted Cushing mattress sutures of fine silk may be used for this layer The ferrules are knocked off the clamps before they are rotated for placement of the anterior row of sutures C The double ferrule has been placed over the tips of both blades and the locking device fastened over the mid portion A running suture of catgut is placed near the clamps anteriorly It is to be noted that straight mosquito forceps are employed to identify the posterior catgut sutures while curved mosquito clamps are used for the same purpose anteriorly D The clamps have been withdrawn the anterior and posterior catgut sutures at each end have been tied together and placement of a row of interrupted Halsted mattress sutures completes the anastomosis *No portion* of the mesentery is employed to secure closure at the mesenteric border

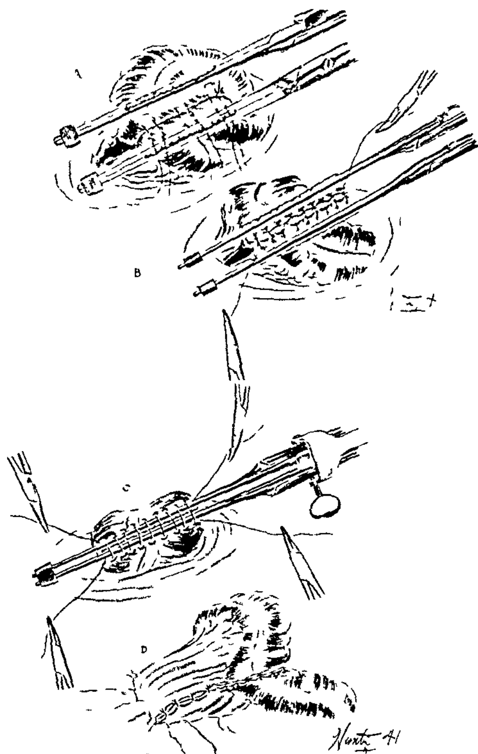


FIG 61—Aseptic (closed) oblique end to-end anastomosis after excision of carcinoma of pelvic colon A Placement of posterior row of sutures Three or 4 Halsted mattress

and the jejunum should lie free below it Nevertheless, because of the nature of the entry of the blood vessels at the mesenteric border, with direct penetration of the circular muscle of the bowel wall, relatively small increases of intraluminal pressure may result in severe damage

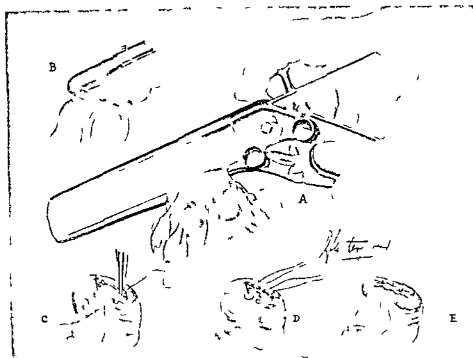


Fig 63—Use of v Petz (2) suturing apparatus in intestinal surgery The instrument is shown here as employed in colonic resection with end to-side anastomosis General adoption of the oblique end to-end anastomosis in all intestinal resections whenever feasible has made use of the v Petz instrument in intestinal surgery rather infrequent The writer uses it regularly when practical however in closure of the duodenum much as is shown here A Application of the instrument B Cutting between the two parallel rows of metal clips deposited by turning the wheel of the instrument with the cautery C Placement of the two semi purse strings at either end D Placement of the Halsted mattress sutures E The inversion completed The turning of the wheel in the right hand of the operator deposits a double row of clips Engagement of the bowel in the instrument at its base suggests that a loop of gut was crushed previously for the first clips deposited by the turning of the wheel emerge at the tip of the instrument (See Figs 62 and 99)

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have been rotated the double ferrule for the anterior anastomosis is in place as well as the holding device over the shank of the clamp The first inner row—a running suture of catgut (000) has been placed Note straight mosquito forceps to identify the posterior running suture and the curved mosquito forceps for the anterior G The clamps have been withdrawn and the second or final and outer anterior row of interrupted Halsted mattress sutures has been placed The writer employs the lateral anastomosis essentially only in entero-anastomoses The oblique end to-end anastomosis is a better and more physiologic operation for primary resection

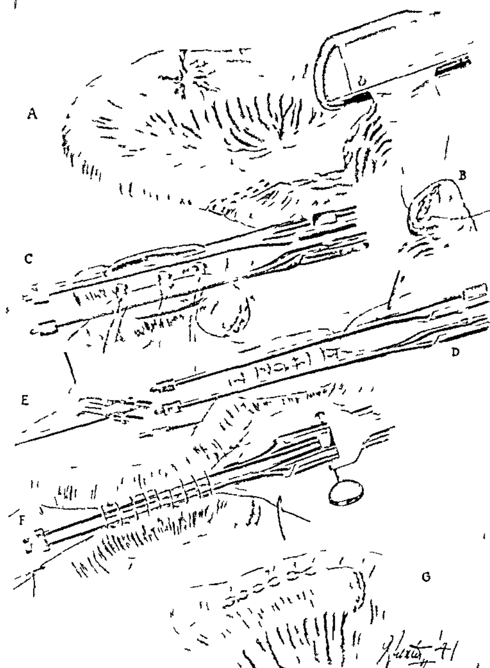


Fig 62—Technical steps in lateral anastomosis of the small intestine employing the v Petz suturing apparatus A Severance of the mesentery and application of the v Petz instrument B The inversion of the blind ends after severance with the cautery C The first posterior row of interrupted Halsted mattress sutures D The second or inner posterior row—a running suture of catgut (000) E Cutting the cuff of bowel above the clamp just before starting the anterior suture Because the blade of the aseptic anastomosis clamp is thin *one must cut the cuff 1 to 2 millimeters above the clamp* F The single ferrules have been knocked off (see Fig 57) the clamps

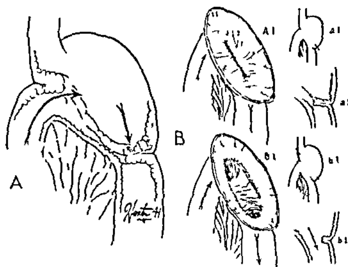


Fig 66.—Mechanism of obstruction at the efferent outlet after gastrojejunal anastomoses A Inversion of too much tissue creates a flap which obstructs at the efferent outlet Obstruction at the afferent inlet through such an agency is distinctly unusual *B* The gastrojejunal stoma after incorrect and correct suture a 1 Oversuturing (incorrect) with narrow stomal slit and obstructing flap at efferent outlet b 1 Wide stomal slit with large patulous stomas at inlet and outlet (correct) after inversion of *.5 cm of the adjacent gastric and jejunal walls* in the anastomosis

of the bowel wall This greater susceptibility to injury of the duodenum over other segments of the bowel, attending increases in intraluminal tension has been described by C A Dragstedt and his associates (1929) and is depicted in Fig 67 In the Billroth II type of gastric resection in which the duodenum is divided and inverted, and, even after gastrojejunostomy

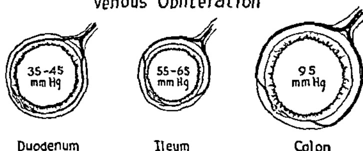


Fig 67.—Venous obliteration attending intraluminal pressure at various levels in the bowel Owing to the immediate penetration of the muscular coat by the vessels at the mesenteric border (5 and 7 o'clock) relatively small increases of intraluminal pressure will cause venous obliteration as contrasted with the colon *where the entry of the vessels* is at 1 and 11 o'clock In the ileum the vessels enter at 3 and 9 o'clock (C A Dragstedt et al Arch Surg 1929)



FIG 64—Reversal of mesentery of one segment of the bowel in oblique end to-end anastomosis as suggested by Dennis (a) Shows the usual manner of dealing with the mesentery and the resultant angulation of the bowel in the dog (b) Dennis scheme of reversal of the mesentery In the bowel of ordinary diameter there is probably little need to reverse the mesentery In the terminal pelvic colon however the surgeon may find it useful in oblique end to-end anastomoses (See also Fig 94)

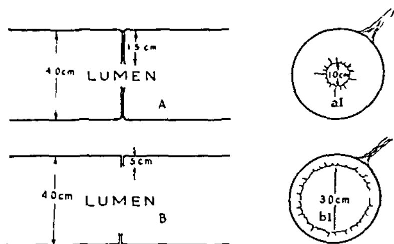


FIG 65—The resultant stoma in end to-end anastomosis A After inversion of a cuff of bowel 1.5 cm in width (overinversion with poor stoma) B After inversion of a cuff only .5 cm in width (satisfactory stoma) Inversion of more than ¾ cm should not be done

and Seley (1939) had administered solutions of sulphanilamide subcutaneously to lessen the hazard of infection from operations upon the colon Subsequently Ravdin and his associates (1940) employed this same expedient to lessen the risks of peritoneal infection, accompanying rupture of the vermiform appendix

The superiority of local implantation of one of the sulfonamides about an operative site, in which potential peritoneal contamination has occurred, resides in this that a considerably higher local concentration of the drug is achieved

Because of the possibility of liver damage attending the use of sulphanilamide, and especially because dangerously high blood levels may attend its use, we have come to rely largely in this clinic on the local implantation of sulfathiazole to reduce the hazards of peritoneal contamination If sulphanilamide is to be implanted intraperitoneally certainly not more than a total of 4 grams and better 2 or 3 grams should not be exceeded Sulfathiazole is a better and safer drug in this respect The writer has on many occasions following primary colonic resections implanted 4 grams in the peritoneal cavity and an additional 2 grams in the incision one gram being placed above the peritoneal closure beneath the muscles, and the other gram beneath the skin, overlying the fascial closure On a few occasions, a total of 7 grams of sulfathiazole has been used Blood levels of 2 to 5 milligrams per cent are usual after this dosage

One of the great advantages attending local implantation of sulfathiazole over sulphanilamide is that the absorption from the local area is slower In consequence, a prolonged high local concentration results with considerably less risk of obtaining dangerous blood levels As far as is known, sulfathiazole does not injure the liver, as does sulphanilamide However, both sulfathiazole and sulfapyridine are eliminated rather quickly in the urine and dosage adequate in amount to provoke a high blood level may cause plugging of the tubules—a danger to be borne constantly in mind Sulfathiazole is superior to sulfapyridine for implantation in that local irritative effects do not attend its use The subcutaneous use of sodium sulfathiazole to prevent urinary tract infection attending use of the inlying urethral catheter will be described subsequently

The local implantation of sulfathiazole about anastomoses performed in the presence of acute intestinal obstruction appears to be fully justified However, it is to be emphasized the local use of the sulfonamides constitute, in no sense a substitute for careful precise, aseptic procedures Febrile reactions, giving rise to anxiety concerning the source of the fever, are provoked occasionally by sulfathiazole It behooves anyone using the drug to lend vigilant notice to the urine output and the occurrence of fever during administration of sulfathiazole

Hawking (1941) has determined, in guinea pigs, the local concentration and the rate of absorption following local implantation of the various sulfonamides Whereas local implantation of crystalline sulphanilamide gives high immediate concentrations because its rate of absorption is rapid after 24 hours, the residual local concentration is slight The local implantation of crystalline sulfapyridine is followed by local concen-

with high grade duodenal obstruction, the occurrence of obstruction at the afferent inlet of the gastrojejunal stoma is a potential disastrous occurrence Whereas, obstruction at the efferent outlet of the gastrojejunal stoma may be well withstood, by a good risk patient for comparatively *long periods of time*, with adequate water and electrolyte replacement, obstruction at the afferent inlet, under the conditions described above, results in a closed loop and potential strangulating obstruction Owing to the secretory activities of liver, pancreas and duodenal and jejunal glands, great increases in intraluminal pressure occurs with loss of viability of the gut wall Patients, in which this complication develops die of hyperthermia, within 36 to 72 hours after operation Experimental reproduction of the syndrome has been done by Lynn, Hay, and Wangensteen (1941)

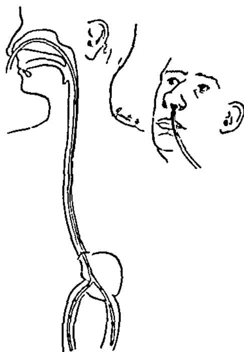


Fig 68—Forked catheter employed to prevent obstruction in the proximal jejunal loop after gastrojejunal anastomoses One limb of the catheter is placed in the distal jejunal loop as well Suction can be exerted simultaneously on the residual gastric pouch the afferent and efferent limbs The tube is removed 72 hours after operation (Surg Gynec & Obst 72 257 1941)

This potential complication of gastrojejunal anastomoses is little known Fortunately, it does not occur often, but, when it does, the patient dies almost invariably A means of insuring protection against this unfortunate contingency is shown in Fig 68 Such a forked catheter, which affords opportunity for exerting suction upon the afferent and efferent loops as well as the small residual gastric pouch has been employed regularly after gastrojejunal anastomoses in this clinic for about two years, and has proved eminently practical The catheter is left in place for three days after operation, the patient being permitted to drink water as soon as he has awakened fully from the anesthetic

E INTRAPERITONEAL IMPLANTATION OF SULFATHIAZOLE ABOUT ANASTOMOSES

The local implantation of the sulfonamides into wounds was instituted by *Jensen, Johnsrud and Nelson* of the Minneapolis General Hospital in 1939 They employed sulphanilamide in compound fractures and noted an astonishing diminution in the incidence of infection Varco (1941) placed sulfanilamide about complicated gastrojejunal anastomoses in the dog, with considerable lowering of the operative risk Previously, Garlock

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trations of about 42 mg per cent, which persist for 7 to 10 days Following local implantation of crystalline sulfathiazole, local concentrations of 104 mg per cent persisting for four days were noted

In this clinic, no determinations of the local concentration of the sulfonamides have been made, other than those published initially by Jensen Johnsrud and Nelson Based on the work of Hawking, just described and our own experience with the blood levels observed in patients after local implantation of sulfathiazole, it would appear that the latter drug satisfies nicely, the requirements of an effective and safe local bacteriotatic agent

F THE OPERATIVE RISKS OF THE CLOSED ANASTOMOSIS

The experience of this clinic with the closed anastomosis indicates that gastric resection for ulcer three quarter resection, excising 75 per cent of gastric tissue, including its complications, other than perforation, may be done *with a mortality of 2 to 3 per cent Gastric resection for malignancy* (80 to 100 per cent excision of gastric tissue) carries a mortality of approximately 10 per cent The difference in operative risk is made up largely by the greater physical infirmities of increased years Primary resection of nonperforated malignant lesions in the colon carries an operative hazard of about 5 per cent Preliminary colostomies are made only in patients who come with obstruction Whether a patient has had a preliminary colostomy does not appear to affect the issue materially

The operative risks of the closed anastomosis, in dealing with the bowel obstruction problem, are a little more difficult to declare First, one would not, by choice, make a primary anastomosis in the colon, in the presence of obstruction Muschkatin is one of the few who advise it for volvulus of the sigmoid flexure (see page 392) Yet as indicated above, in the chapter on choice of operative procedure, in obstructions of the small bowel brought about by malignant lesions the present policy, in this clinic, is to perform primary resection, wherever feasible Similarly, with strangulating obstructions, in the small intestine, primary resection with oblique end to end anastomosis is considered to be the operation of choice *Yet, in any clinic during the interval of a year's time relatively few such cases, demanding excision of the bowel during the presence of acute* obstruction are seen During the past year 8 such primary resections were done in this clinic by Dr Clarence Dennis and the senior surgical house officers There were no deaths However, it is to be admitted freely that in a large group of cases, the factors of strangulation including its threats of impaired viability of the bowel wall and blood loss, and distension with its difficult problems—these items involve risks, at least in the light of present experience, considerably greater than those listed above in operations of election upon the gastro intestinal canal Certain it is the risks of primary resection for strangulating obstruction, are so far better than any other method of dealing with this type of obstruction that the practice of protracted efforts at achieving decompression by conservative means in patients who may have strangulating obstruction, should be discontinued

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Chapter IX

POSTOPERATIVE TREATMENT

A. CARE ON COMPLETION OF OPERATION

Postoperative treatment begins when the dressings have been applied on completion of the operation In this clinic inhalation anesthesia, ordinarily intratracheal cyclopropane is the anesthetic agent which enjoys widest use The first concern of the surgeon, after the operation is finished is that the pharynx of the patient is dry To this end, during the latter part of the operation (abdominal closure) the anesthetist tilts the head

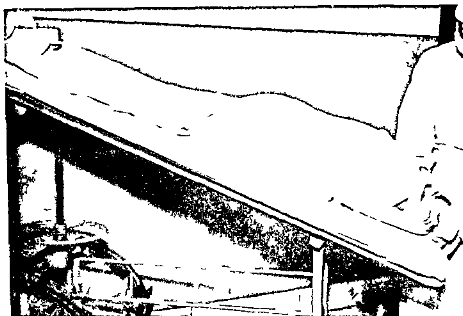


Fig 69—Mode of transfer of patients who have undergone long and difficult operations from the operating room The interne is supporting the patient's jaw and the patient is on his side in the Trendelenburg posture

of the table downward into a moderately steep Trendelenburg position to facilitate gravitation of tracheal fluid or mucus into the pharynx The pharynx is aspirated with a urethral catheter until the patient is quite dry During operation the anesthetist aspirates through the intratracheal tube as frequently as is necessary

When the patient is placed on the litter for transport to his room he should be placed on his side to avoid posterior displacement of the tongue into the pharynx which accident is more likely to occur in an unconscious patient transported in the supine position If the operation has been long

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meters of mercury as indicative of the presence of threatening shock and to treat the patient accordingly In the experience of the writer, the gravity method of transfusion of citrated blood is the most convenient Save for the depression of arterial pressure attending the use of spinal anesthesia there are few indications for employment of vasospastic agents, such as adrenalin or ephedrine in the treatment of shock

In this clinic it is routine practice to insert a needle into one of the ankle veins of the patient, having major abdominal surgery, on the operat

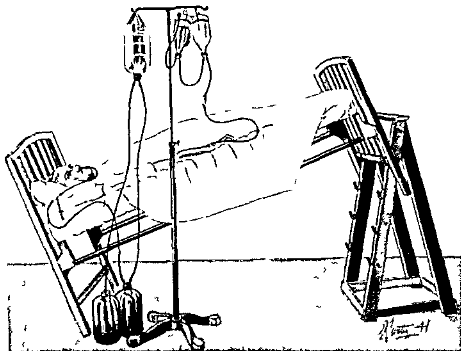


Fig 70—Use of shock frame in recovery period (see text) Note insertion of needle into vein on dorsal aspect of forearm permitting free motion of patient s forearm (see text) The three bottle suction apparatus is shown also The catheter is anchored to the upper lip with adhesive tape

ing table just before commencement of the operation Saline solution is allowed to run in very slowly If the operation is long and tedious if blood loss is of such an order as to warrant blood replacement or if the patient s condition suggests the need for it a transfusion of blood or plasma is given through this ankle vein needle during the course of the operation With this practice startling surprises in the appearance of shock in patients prepared adequately for operation on return to the ward are very unusual The anesthetist's record indicates how much fluid, plasma or blood the patient was given in the operating room

To be certain, every patient operated upon need not be transfused Yet the blood loss in operations, in the main even amongst surgeons

and tedious, or, if the blood pressure hovers around the shock level of 100 mm Hg or less, the patient should be transported in the head down position (Fig 69) No patient in shock should leave the operating room until the shock has been treated adequately It is a mistake to hurry the patient out if shock is present or impending Two attendants should accompany the patient from the operating suite to his room

B CARE OF THE PATIENT ON ARRIVAL AT THE WARD

Every anesthetized patient who has had a *major surgical procedure* on the surgical service of the University Clinic is placed on a shock frame as indicated in Fig 70 This position gives assurance on two points 1 Any secretions *in the trachea or larynx will gravitate to the pharynx* from which point of vantage, they may be aspirated more readily 2 The blood pressure is supported satisfactorily

Every *anesthetized patient must have the constant and undivided attention* of a nurse until the patient is awake and fully oriented During this period, the suction apparatus is attached again to the indwelling duodenal tube All patients who undergo abdominal surgery of a major character by the writer have an indwelling duodenal tube inserted into the stomach an hour or two prior to operation Suction is in force *before* operation *during* operation and *uninterruptedly* during the first few days of the recovery period The only time, during which suction is not in force, is the few minutes occupied by the transport of the patient from the operating suite to his room The constant application of suction insures an empty stomach and when combined with a judicious use of the Trendelenburg position, affords the best protection against the development of post operative pneumonia Aspiration into the lungs is, without doubt, the most important cause of pneumonia after operation

C SHOCK

The immediate concern following operation is that the patient is returned to his bed with evidence of satisfactory status of the circulation If the systolic blood pressure is less than 100 millimeters of mercury and the fluid administration has been liberal the foot of the bed should be elevated on a shock frame (Fig 70) Whereas it has been alleged (Cannon 1923) that this expedient has no virtue in the treatment of shock, trial will demonstrate that the rationalizations which proved it ineffective were based on false premises Its frequent use after potential shock producing operations, as an extensive thoracoplasty, has decreased the necessity of combatting shock by more energetic agents such as transfusion of blood or plasma If the systolic blood pressure is not sustained above 100 millimeters of mercury elevation of the foot of the bed on a shock frame intravenous infusion of a crystalloid solution (5 per cent glucose in distilled water or saline solution), and transfusion of blood or plasma should be successively tried It is not wise to permit the systolic blood pressure to remain far below the normal level for long Eighty millimeters of mercury is usually considered to be the critical level of blood pressure the writer prefers to consider a systolic pressure of less than 100 milli

who is awakening from the effects of an inhalation anesthetic, frequently has a good deal of mucus in his mouth and pharynx probably as a result of irritation of the tracheal and bronchial epithelium The danger of aspiration asphyxia, in such a patient who has not yet regained his cough reflexes is real, if he is returned to bed with his head higher than his trunk

The Fowler or semi Fowler position is much overused by surgeons generally Probably the only indication for its use in abdominal cases is when one hopes to influence the site of collection of exudate in an intra peritoneal abscess by the force of gravity In the main, in the early post operative period, the low position of the head is the best When it is definitely known that shock will not develop and the patient has fully recovered from the effects of the anesthetic, the shock frame can be lowered from beneath the foot of the bed Until the patient becomes active, usually three or four days after operation, it is a good plan to keep the foot of the bed on the lowest rung of the shock frame or on low props, in order to insure an unobstructed flow of blood from the lower extremi ties The writer prefers to have the patient lie with the head on one pillow with the bed horizontal well into the recovery period, sitting up in bed only for meals

Frequent postoperative change of posture has superseded routine em ployment of Fowler s position as being more acceptable Every two hours day and night, except when the patient is asleep, his position in bed is changed by attendants in the following manner he lies two hours on his back, then two hours on one side, then two hours on his back again, followed by two hours on the other side, and so on In this clinic, unless there be some strict contraindication directly after operation every patient is urged to move his arms and legs freely, "a thousand times a day' — an admonition which is pressed on him until he becomes ambulant This exhortation is repeated to him by nurses and interns so that he is kept mindful of the counsel These injunctions relate to patients, who have been operated upon for bowel obstruction with equal force, as they do to other intra abdominal conditions

E PULMONARY ATELECTASIS

When the peritoneal cavity is opened some very interesting physiologic phenomena occur in consequence One of these is the inhibition of move- ment of the diaphragm this happening has been much investigated, but what causes it has not been determined It would appear to be a reflex phenomenon and apparently sets in as soon as the pain sense returns (Carlson 1932) This circumstance undoubtedly relates itself intimately to the occurrence of pulmonary atelectasis This impaired mobility of the dia phragm is more apparent following upper abdominal operations than after lower and lasts well into the convalescent period Any stimulus to respira tion such as the periodic inhalation of carbon dioxide will affect this in hibition favorably but only as long as respiration is thus artificially stimulated The value of hyperventilation with carbon dioxide in obviat ing this constant accompaniment of abdominal operations has undoubtedly been overrated The writer prefers to have the patients cough two or

who practice the strictest hemostasis, is greater than is appreciated generally Gatch and Little (1924), Maddock and Coller (1937) and White and his associates (1938) have measured the blood loss in various types of operations Their findings substantiate this statement Transfusion is not to be employed as a substitute for careful hemostasis

In patients, who come to the clinic with a high grade anemia and who present a formidable surgical problem in the excision of their tumor or the correction of their surgical lesion, a number of transfusions are often necessary Following the suggestion of DeGowin and Hardin (1940, 1941), in patients needing multiple transfusions of blood, it has become routine practice, in this clinic, to give such patients a liberal supply of sodium bicarbonate by mouth (10 15 grams) or a 5 per cent solution intravenously (250 cc) daily to insure an alkaline urine It is DeGowin's contention that albuminous casts in the renal tubules are much less likely to form attending hemolytic reactions if the urine is alkaline Though such reactions are infrequent, they are unfortunately followed by oliguria and often, fatal anuria A number of such reactions, accompanied by fatal anuria have occurred in transfusions involving group 'O' donors and recipients Witebsky and his associates (1941) have described recently addition of A and B substances to the transfused blood to remove A and B and R_h agglutinins Such an aid, if proved practical, would be a great boon to surgery

In the experience of the writer, such plugging of the renal tubules with albuminous casts, as a consequence of transfusions has been observed more frequently in anesthetized patients transfused with stored blood during or immediately after operation Whether anesthesia per se may contribute to its occurrence is not known Nevertheless, the writer is inclined not to employ the blood from more than one donor during or immediately after operation By preference therefore, such patients are given plasma, if blood loss replacement is indicated If colloidal infusions beyond the amounts of plasma available are required, a single transfusion of blood is given Under unusual circumstances, of course it becomes necessary, occasionally, to set aside this guiding rule in the interests of supporting a falling blood pressure, by giving blood from more than one donor

It is a task of some magnitude to impose responsibility on a hospital staff, for providing enough available plasma from blood donors to carry patients needing formidable operations through their hospital stay Yet, this effort is justified fully in the avoidance of hemolytic transfusion reactions and their consequences

The search *for a satisfactory blood substitute which will be readily* available for treating shock is very much worthwhile Bovine albumin, or some other suitable substitute for human blood or plasma, may some day fill that much needed want

D POSITION IN BED

The position of the patient in bed is important A patient, who has not fully regained consciousness, must be placed with his head lower than his body trunk, to prevent aspiration of saliva into the lungs A patient,

is extremely important (Fig 72) The status of chlorination of the patient can be determined by rules outlined previously Average amounts of sodium chloride lost in gastroduodenal aspirations average about 5 grams per liter and for perspiration about 3 grams per liter (Coller and Maddock) Minimal quantities of salt are lost in the insensible perspiration Determination of the fluid losses the daily excretion of sodium chloride in the urine and an occasional plasma chloride determination, when and

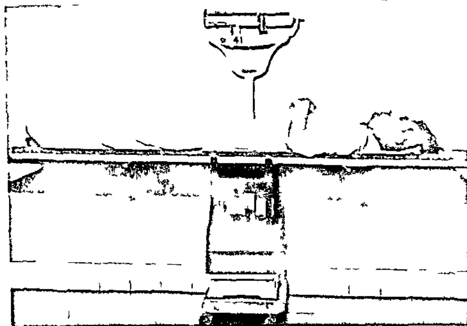


Fig 71—Manner of obtaining bedside weights of patients after operation The block on the scale supports the stretcher Significant gains or losses in weight may be detected readily The weighing of patients before and after operation has come to be an important item in determining the status of hydration in this clinic (Surg Gynec & Obst 72 257 1941 Feb 2A)

where needed will give excellent orientation concerning the sodium chloride balance Excesses of sodium chloride should not be given lest edema occur There is a definite lag *in the excretion of excessive amounts* of sodium chloride and in the patient with poor cardiac reserve such sodium chloride retention with consequent water retention may invite pulmonary edema and other undesirable sequelae

Water Requirements

If the patient presents a normal state of hydration prior to operation, postoperative weighing of the patient is an excellent guide to maintenance of an approximately normal fluid balance (Fig 71) For patients undergoing operations of election this is an excellent expedient and one that extensive trial, in the University of Minnesota Surgical Clinic has demon

three times following a deep inspiration, while the nurse compresses the lower chest and abdomen, thus protecting the incision with the avoidance of pain This maneuver is repeated many times each day during the early recovery period

With opening of the peritoneum, a temporary cessation of intestinal movement occurs This circumstance may be observed also in drainage through an enterostomy opening made for the relief of mechanical obstruction during the early postoperative period This phenomenon of impaired motility of the gut gives rise to *distension with its accompanying* sequelae It is difficult at times to escape the impression that a patient after operation may not swallow more air than he otherwise does Definite proof of this however, is lacking It has been related already how a dog with a transected cervical esophagus will swallow a good deal of air unless the distal end is turned in (p 17) Whereas ordinarily air is brought into the stomach only in deglutition, apparently such an animal may swallow air coincidental with respiration Determination of pressures in the esophagus of a few such animals showed that subatmospheric pressures were often present It is altogether possible, of course, that the sphincters of the esophagus in postoperative patients may so behave as to permit abnormal entry of air into the stomach Suction applied to an indwelling duodenal tube is the best means of mitigating the effects of paresis of the bowel associated with intraperitoneal operations

F PREVENTION OF THROMBOSIS

Another consequence related to the two preceding items, viz , inhibition of diaphragmatic motion and paresis of the gut, is the slowed circulation in the lower extremities Keeping the foot of the bed elevated and urging active motion on the patient serve to prevent stagnation of blood in the veins of the lower extremities Intestinal distension impedes the venous return from the lower extremities too (Bellis and Wangensteen 1939) It is not unlikely therefore, that these two same occurrences may be related fairly directly to the problem of postoperative thrombosis and embolism The more frequent occurrence of embolism after abdominal operations than after others is well known In the instance of the prostate, this circumstance is best shown The suprapubic method of prostatectomy with an abdominal but extraperitoneal incision is followed by a greater incidence of embolism than attends the perineal or intravesical methods of removal The latter two methods of approach are not often attended by inhibition of diaphragmatic motion and meteorism

The frequent change of posture and assumption of active movement aid in accelerating the venous return from the lower extremity as probably does also the prevention of intestinal distension

G THE POSTOPERATIVE ADMINISTRATION OF FLUID

Sodium Chloride Needs

The guiding rules formulated on page 132 are applicable here The daily careful summation of fluid intake urine output, and other fluid losses

fluids administered subcutaneously are given on the external aspect of the thigh, beneath the fascia lata

For the administration of concentrated solutions of glucose (20 per cent) described below, as well as for infusions of blood, plasma and amino acids, the intravenous route must of course be used The too rapid infusion of high concentrations of glucose solution results not alone in the loss of glucose in the urine but in a loss of interstitial fluid with dehydration as well (Keith 1929) Ordinarily 3000 to 4000 cubic centimeters of para oral fluids a day (best given slowly by the intravenous route in a morning and evening administration) suffice If there be any doubt about the status of hydration an accurate check of the hemoglobin, together with determination of the specific gravity of the plasma especially if preoperative values are available, affords reliable information concerning the fluid requirements of the patient With employment of suction patients may be permitted water by mouth directly after operation The mouth should be kept moist and clean to preclude the occurrence of parotitis

II MAINTENANCE OF CALORIC AND NITROGEN BALANCE

For many years now surgeons have been alert to the water and electrolyte requirements of patients undergoing operation Apart from giving enough glucose to avoid the ketosis of starvation little interest has been taken by surgeons in the general problem of meeting the caloric requirements of the patient And practically no notice has been given the item of maintaining the patient in nitrogen equilibrium In a sense physiological teachings have been responsible for this neglect on the part of surgeons Medical students are being reminded constantly how long men have gone without intake of food Most men undergoing such trial periods of starvation however come to the ordeal well prepared in a good state of health Patients frequently come to the surgeon after long periods of starvation and undergo at his hands procedures involving great risks which test crucially the capacity of the body to withstand operative trauma with no further preparation than to make certain that severe anemia is not present and that the water and electrolyte requirements are met In addition to the uncompensated preoperative starvation and the trials of operation such a patient must bear too the burden of starvation enforced by the recovery period

This practice obviously is wrong and should be discontinued A maximal effort should be made by the surgeon to bring his patient into caloric and nitrogen equilibrium before operation is undertaken Poor risk patients who exhibit great weight loss from obstruction at the gastric outlet present the most difficult type of problem The intestinal canal cannot without the performance of a preliminary enterostomy be used for purposes of feeding Inasmuch as no ideal enterostomy feeding mixture is available and because enterostomy alone for such patient is sometimes a difficult burden it has been the practice of this clinic to prepare such patients for operation by intravenous feeding

Whipple and his associates have demonstrated that a dog may be main

strated to be superior, at least in our hands, to all other methods in avoiding large fluctuations in weight and in approximating the normal status of hydration An ordinary bedside scale, *equipped with a block to* hold a litter carrier, answers the purpose adequately Experienced nurse will weigh patients on such a scale to an accuracy of about 100 grams It is weight disparities, beyond 1 to 2 kilos, in the adult of average weight, that concern us Every patient undergoing surgery of a major character, at the hands of the writer, is weighed, several times before operation (whenever possible) and daily, each morning after operation When the *patient supports himself on an oral intake and meets his fluid require* ments by satisfying his own thirst, weighing is no longer necessary

In obstructed patients, whose status of hydration may have been far from normal on admission, weighing is not of so much value The excretion of 800 to 1000 cc of urine daily suggests that the fluid requirements of the patient have been met The amounts of fluid necessary to meet the requirements of patients have been discussed previously (page 133) It is to be remembered that anesthesia has a profound effect upon vaporization of fluid from the skin The surface capillaries of the skin are dilated with increased fluid loss Inhalation anesthesia affects all the surface capillaries in this manner *Spinal anesthesia causes increased loss of fluid* only from the anesthetized surface areas

It may be necessary to determine the hemoglobin and compare the reading with preoperative values to determine whether hemoconcentration or dilution has occurred Periodic determination of the plasma proteins by the falling drop according to the method of Barbour and Hamilton (1927) gives added information concerning the status of hydration In this *hospital standards made up by Bellis have been employed to determine* the specific gravity of the plasma

The Kind of Fluid

For the usual patient with obstruction, 3000 to 4000 cc of parenteral fluids suffice Patients presenting obvious evidences of dehydration need more (see page 133) Once the losses of sodium chloride sustained by vomiting have been replenished unless the gastroduodenal aspirations are great, 4 to 9 grams of sodium chloride will meet the situation adequately If more than 3 grams are excreted daily in the urine even this amount (9 grams) is too much The remainder of the fluid is to be made up by varying concentrations of glucose in distilled water

Routes for Administration of Fluid

After abdominal operations of a major character, only the subcutaneous and the intravenous routes are to be depended upon for the administration of fluid In the main, unless the rate of flow is adjusted carefully, it is better to give saline solution or 5 per cent solutions of glucose under the skin The too rapid intravenous administration of fluid is hazardous, especially in poor risk patients Yet, in dehydrated patient the intravenous route is to be preferred to subcutaneous administration In this clinic, all

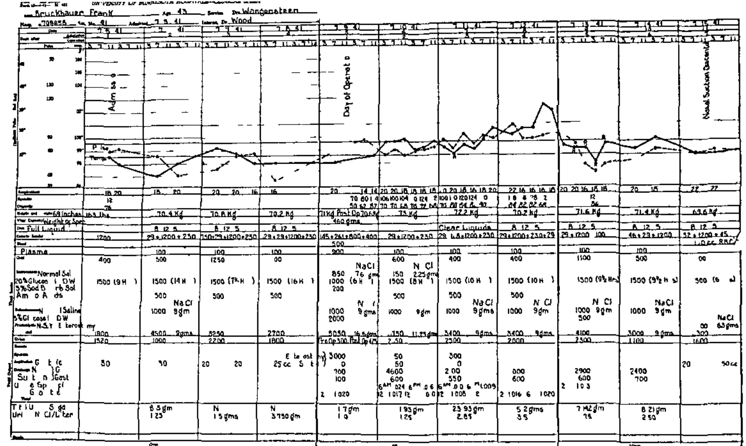


FIG 72—Photograph of hospital record indicating the mode of pre- and postoperative management The patient had total gastrectomy for cancer Nitrogen balance was maintained by the intravenous administration of amino acids supplemented by plasma and 1500 cc of 20% glucose solution was given daily The febrile response on the 4th postoperative day followed intravenous administration of amino acids The patient was dismissed 12 days after operation

tained in nitrogen equilibrium by the intravenous administration of canine plasma, without-exogenous food intake In this clinic, similar observations have been made on man with human plasma It has been shown, too, that bovine plasma may be given to man and that nitrogen equilibrium may be maintained through such an agency It is to be admitted freely, however, that the administration of bovine plasma to man is still an experimental venture, even though amounts in excess of 2500 cc have been given to more than 150 patients in this clinic Bovine albumin (Cohn) appears to have more promise

Ravdin and his associates have stressed the great value of simultaneous feedings of adequate amounts of protein and carbohydrate in maintaining normal glycogen stores in the liver, and in replenishing them after periods of starvation They have shown, also, that oral feeding is more effective, in this respect, than is intravenous feeding

Intravenous Administration of Nitrogen

It is doubtful whether nitrogen equilibrium may be maintained by the administration of amino acids, now commercially available Whipple and his associates have shown, however, that addition of small amounts of methionine and trytophane to one of the amino acid solutions, prepared from a casein digest will maintain nitrogen balance The work of Ro e, Elman and Whipple and their associates has done a great deal to develop a practical way of maintaining nitrogen equilibrium in surgical patients The addition of methionine and tryptophane makes of the amino acid mixture, a fairly complete protein and supplies the missing essential amino acids The casein, from which the amino acids are prepared by a combination of enzymatic digestion and acid hydrolysis, is a complete protein, but some of the essential amino acids are lost apparently in the manufacture of the digest Plasma, being a complete protein, constitutes a satisfactory source for the maintenances of nitrogen balance, on intravenous administration

A patient receiving a protein sparer (glucose in adequate amounts), can be maintained in nitrogen equilibrium on a relatively small nitrogen intake Five to six hundred cc of plasma will suffice It is debatable, however, whether it would be wise to give a patient that amount of plasma intravenously, each day, lest the injection of this colloidal fluid might increase the blood volume and invite heart failure, in patients with poor cardiac reserve It has been our practice to give, daily, 500 cc or more of one of the commercially available amino acids (Stearns nitrogen content 2 4 grams per cent, Mead Johnson 1 6) This amount of nitrogen will approximate maintenance of nitrogen equilibrium, when supplemented with 200 cc of human plasma given in 100 cc amounts twice a day This scheme has proved eminently practical and a large number of poor risk patients have been prepared for operation in this manner In order to initiate the storage of protein in the liver, however it is obviously necessary to give more than enough nitrogen to meet the energy requirements of the patient Plasma meets this latter requirement best in that the urinary excretion of nitrogen is not augmented by the intravenous injection of plasma, as attends the intravenous injection of amino acids—the protein of injected plasma being available for purposes of increasing the depleted stores of de

the operative attack be a direct one in which the obstructive mechanism is undone, or indirect, in which external drainage is accomplished by enterostomy, because of the paresis of the bowel incident to operation, suction should be continued well into the convalescent period in every obstruction It is the writer s practice to employ suction routinely after all operations for obstruction—even after surgical relief of acute obstruction of the colon in which the small intestine does not participate in the distension The exertion of continuous suction upon an indwelling catheter in such instances prevents prophylactically the occurrence of general intestinal distension incident to operation In infants, suction should not be long continued into the postoperative period without interruption because of the danger of otitis media owing to the presence of the tube in the pharynx As the quantity of gas and fluid returned by the siphonage diminishes, suction may be interrupted by intermittently clamping the tube and when discontinuance of suction, over a three or four hour interval causes no distress the tube may be removed It has been the writer's practice al o to apply suction to an enterostomy tube largely so that the gas and fluid returns may be accurately measured In the main, it may be said that the amounts aspirated through the duodenal tube are usually considerably greater in amount only in the presence of high grade obstructions does the postoperative drainage through an enterostomy catheter approach the aspirations made simultaneously through the indwelling duodenal tube The indication for removal of an enterostomy tube is ability on the part of the patient to tolerate it being clamped without occasioning him distress The writer's usual practice is to keep the tube in situ until the patient becomes ambulant, about the tenth or twelfth day A valvular enterostomy well made will not leak on withdrawal of the tube

J BOWELS

The employment of suction well into the convalescent period has practically done away with the need for enemas to obtain relief from distension After abdominal operations of diverse natures in which this expedient is employed during convalescence, patients not infrequently go five to seven days without a bowel movement and without distress so similarly after operations for the relief of mechanical obstructions An enema may be given at the end of this period or mineral oil may be permitted by mouth Enemas during the early postoperative period should be discouraged They are usually ineffectual and may do harm Pituitary extract or other stimulants of intestinal activity, such as physostigmine or pilocarpine have been employed rarely by the writer Undoubtedly there are isolated instances during the postoperative period when distension may be more effectually combatted by their u e The writer however inclines strongly to the passive treatment of distension as opposed to the active means of enhancing intestinal contractions One of the best and probably the safest means of stimulating a di tended bowel is to decompress it

K AVOIDANCE OF PULMONARY COMPLICATIONS

Prevention of regurgitation of gastric content or aspiration of mucus or saliva into the lungs is undoubtedly, the most important factor in the

The plasma protein values are not depreciated significantly in some patients who come with a moderately long history of starvation Moreover, it is far more important to learn, from the patient himself, that three or four weeks have elapsed, during which time, there has been almost absolute starvation with a long period of relative starvation preceding

Intravenous Administration of Glucose to Maintain Caloric Balance

For a period of approximately two years, a 20 per cent solution of glucose has been given intravenously, in an effort to maintain caloric balance in patients with obstructions in the gastro intestinal canal—largely, patients with obstructed stomachs If a 22 gauge needle is employed in a forearm vein as shown in Fig 71, the patient is allowed full range of motion, and, the rate of flow may be adjusted in such a manner that only 100 to 150 cc of the solution runs in per hour It is not difficult to provide a patient with 1500 cc of a 20 per cent solution of glucose in this manner each day, over a short period of time Daily quantitative determination of the amount of glucose spilled in the urine affords an accurate check of utilization The serious drawback to the protracted use of a concentrated glucose solution in this manner is that, the veins become thrombosed In addition local swelling accompanied by slight pain, occurs now and then Yet, employing a combination of 20 per cent glucose solution and amino acids and plasma as outlined above, a number of poor risk patients have been prepared for operation and carried successfully through the recovery period after operation by this means until they can eat Such patients gain in weight and strength and exhibit other discernible effects of improved health, while being prepared for operation on this regimen

After gastric operations Ravdin and his associates have employed jejunal feedings, introduced through an inlying two way duodenal tube suction being applied to that portion of the tube lying within the stomach The writer prefers to keep the upper reaches of the intestinal canal empty and finds intravenous feedings as outlined above very satisfactory Intestinal paresis incident to operation impairs intestinal transport Keeping the upper reaches of the gastro intestinal canal empty during the first few days of the recovery period is, without question, an important item in the prevention of pneumonia It has been our practice to withdraw the forked indwelling duodenal tube, employed for purposes of expressing suction on the residual stomach, afferent and efferent limbs of the gastro jejunal anastomosis 72 hours after operation The patient must then continue to have his oral intake complemented, in part by intravenous feedings, until the oral intake is adequate to support a satisfactory nitrogen and caloric balance

Search for another satisfactory agent by which caloric balance may be maintained, by intravenous injection without inviting thrombosis is laudable No evidence has been noted that slow intravenous injection as indicated above, favors the occurrence of heart failure

I DISTENSION

Suction is the most effective agency in combating distension Even when a mechanical obstruction has been relieved by operation whether

Hiccuping, though inexplicable in many situations is essentially an irritative phenomenon involving the diaphragm and is most likely to present itself in situations which involve peritoneal irritation In the Whipple operation for excision of the head of the pancreas for carcinoma—an operation which involves usually some leakage of pancreatic juice into the peritoneal cavity, persistent hiccuping has been a rather frequent complication Now and then, firm pressure over the transverse process of the sixth cervical vertebra, with the patient s head turned appropriately to



Fig 73—Use of the Boothby Lovelace mask for the administration of high concentrations of oxygen The inlying duodenal tube goes through the mask

the side will compress the phrenic nerve and arrest hiccups In the most persi tent cases the treatment which has been found to be most effectual in this clinic is to inject one of the phrenic nerves with 1 per cent novocaine employing 30 to 60 cc If hiccups return after a few hours the other phrenic nerve is injected similarly After a few trials one learns which phrenic nerve is influenced most favorably by the injections This information can not be gotten if both nerves are injected at the same time Repeated subcutaneous injections of novocaine into the immediate vicinity of that phrenic nerve apparently influenced most by the irritative process constitutes the most effective way of arresting hiccups In this clinic over a period of years, only one patient has had to have cervical crushing of one phrenic nerve to stop persistent hiccuping Injections of novocaine controlled the hiccups effectually in that patient, but the necessity of frequent repetition of the injections suggested phrenic crushing as a more satisfactory therapeutic expedient

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prevention of pneumonia The avoidance of pulmonary edema, by the too rapid intravenous administration of fluid or administration of too much fluid by any route, constitutes prophylaxis against the development of pneumonia Aspiration of the pharynx and larynx and stomach well into the operative recovery period, turning the patient frequently, and, enjoining on him the necessity of active motion are all important items in preventing pulmonary congestion

Despite all these measures, pneumonia still occurs Yet, now with sulfathiazole and sulfapyridine, the risks of pneumonia have been reduced considerably Both these drugs, if present in the blood stream in sufficient concentration, may cause plugging of the renal tubules Employment of large intravenous doses are, therefore, to be avoided In this clinic, the administration of sodium sulfathiazole in sufficient amounts by the subcutaneous route *(1 gram per 125 cc of saline solution) to maintain a blood* level of 5 to 6 milligrams per cent is the method of choice Four to six grams daily suffice usually Dramatic improvement attends often its use, in this manner Dr W W Spink, Associate Professor of Medicine, has afforded us great help by his counsel and writings in the management of postoperative patients with pneumonia Sulfathiazole and sulfapyridine, unlike sulphanilamide hold out no serious threat of causing liver damage It is to be remembered that sulfathiazole may provoke fever occasionally

An antecedent of pneumonia following many abdominal operations is undoubtedly, pulmonary atelectasis related to the temporary impairment of diaphragmatic excursion described above There are probably inter phases in which the administration of one of the effective sulfonamides may thwart development of pneumonia from such a source

L RETENTION OF URINE

Most patients will void without great effort after operation Inability to void in the early postoperative period is considerably more frequent attending employment of spinal anesthesia Catheterization is in order when the patient is in distress and can not void spontaneously

In operations of some magnitude, the writer has come to insert a urethral catheter as a matter of routine Accurate determination of the daily urine output is attainable in this manner, the urine bottle being changed each morning at precisely the same hour The daily administration of two grams *of sodium sulfathiazole subcutaneously in saline solution (twice daily in* one gram amounts in 150 cc of saline solution) will suffice to avoid urinary tract infection from the inlying catheter

M HICCUP

The indwelling duodenal tube is ordinarily the best prophylaxis against hiccups Yet, patients may develop hiccup with a tube in place functioning properly Abolishing this troublesome postoperative complication is often a trial and error process *in which one tries the lesser remedies first,* reserving the more aggressive therapeutic agents for the more refractory cases Adequate sedation in many instances is helpful Inhalation of high concentrations of oxygen, employing a Boothby Lovelace mask has proved extremely helpful in many trying cases

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TABLE XXV —MORTALITY OF ACUTE INTESTINAL OBSTRUCTION

Author	Year of Report	Number of Cases	Mortality (Per Cent)
Scudder	1907	121	60
McGlannan	1913	181	37
Deaver and Ross	1915	276	42
Codman	1920	41	34
Richardson	1920	118	41
Flint	1921	283	15 6
Braun Wortmann	1924	379	39
Souttar	1925	3064	26
Tuttle	1925	150	50
Holden	1926	135	19 2
Brill	1929	124	36
Miller	1929	343	61
Smithies	1930	56	41
Cornell	1932	235	51
McIver	1932	156	44
Vick	1932	6892	26
Vidgoff	1932	266	46
The Suction Period			
Wangensteen and Paine[1]	1933	32	15 6
Wangensteen et al[2]	1938	157	17 9
Johnston[3]	1940	63	19 1
McKittrick and Sarris	1940	136	20
Leigh Nelson and Swenson[4]	1940	76	13 2
Lewis Shapiro and Vaughn	1940	262	21 7
Schlicke Bargen and Dixon[5]	1940	133	21 8
Dennis and Brown[6]	1942	48	13 3

Selected personal series

[1] Only 2 staff members were responsible for management of these patients in the subsequent report (1938) 14 staff members participated

[2] 157 patients had 190 obstructions case mortality 14 7% Decompression achieved by suction above in 43 6% Mortality in suction group (without operation) was 7 8%—the mortality by case was 6%

[3] Johnston s series does not include strangulating obstructions

[4] Authors included 12 cases of intestinal distension not essentially mechanical in origin Mortality in mechanical obstruction group was 15 6%

[5] Mortality amongst 33 additional patients with strangulating obstruction was 24 2%

[6] Mortality during second half of period since report of Wangensteen et al in 1938

suction period as suggested by the latter reports listed in Table XXV a definite lowering of the mortality has come about

A number of factors contribute still to continuance of a mortality which should become lower As a number of reports have indicated the two chief stumbling blocks to better accomplishment with the bowel ob struction problem are (1) strangulating obstructions and (2) great dis *tension in patients coming to* operation In the series of McKittrick and Sarris strangulating obstruction was responsible for 59 per cent of the mortality and the problem of distension presented at operation accounted for 30 per cent of the deaths

CHAPTER X

THE MORTALITY OF ACUTE INTESTINAL OBSTRUCTION

A THE MORTALITY OF BOWEL OBSTRUCTION

UP UNTIL a few years ago, the universal complaint was that the mortality of operation for intestinal obstruction had exhibited *no improvement since* the beginnings of abdominal surgery, when it was debated whether medical or surgical *management had most to offer patients with obstruction* A number of statistical studies indicated that this complaint was a just one *A number of studies indicated*, at the same time, that distinctly better results were obtained in those cases submitted to operation early In 1899 Sir Frederick Treves said, "Those who are enamoured of statistics could, I have little doubt show that it is less dangerous to leap from the Clifton Suspension Bridge than to suffer from acute intestinal obstruction and decline operation" The experience of the past ten years has demonstrated that a number of patients can be decompressed satisfactorily, without recourse to operation Yet, in the pitfall of treating a patient with an indwelling duodenal tube, who should be submitted to early operation lies *a real danger*

Recent studies have shown a fairly general decline in the mortality of bowel *obstruction for the first time* Nevertheless, *of the cases that do die* procrastination until it is too late is often an important factor in the lethal issue *The admonition of operating early* urged so frequently by experienced abdominal surgeons a decade and more ago, needs re emphasis today, for many kinds of bowel obstruction

At the Massachusetts General Hospital in Boston, there has been a keen interest in the bowel obstruction problem for many years, McKittrick and Sarris (1940) have reviewed recently the mortality of acute mechanical obstruction of the small intestine in that hospital Previous reports, covering periods from 1898 up until 1928, have been made from the same hospital by Scudder (1908) Richardson (1920) and McIver (1932) Whereas, *there was evidence of some improvement* between the report of Scudder and McIver, for the first time in the history of that hospital, a distinct betterment in the results *of treatment has become manifest* The tabulated data covering the forty-year period from 1898 to 1938, are summarized in Fig 74 The present hospital mortality *of 20 per cent is only one third of* the initial mortality reported by Scudder It is to be noted, too that the number of patients submitted to early operation has *increased remarkably*, even during the years that suction, as a mode of treatment has been gaining favor

The accompanying table, representing essentially a tabulation from McIver's (1934) monograph on obstruction indicates that, with few exceptions, the general mortality was essentially that reported in previous decades from the Massachusetts General Hospital With advent of the

In addition, there is the hazard of treating patients by conservative management (suction) too long When these patients come to operation later the technical problem is far greater, occasionally, than it would have been, *had operation been undertaken initially* This increased hazard concerns essentially two things (1) distension, increased in amount, over that present initially, and (2) decreased breaking strength of the bowel On the gentlest manipulation, the peritoneal coat tears and after days of obstruction, as was pointed out previously, adhesive bands may become fused with the gut wall such that cutting or freeing them or any manipulation directed at removing the obstruction may cause accidental opening of the bowel with spillage at the site of fusion of adhesive bands and bowel wall

The possibility of failure to achieve satisfactory decompression with conservative means (suction) prompted McKittrick and Sarris (1940) to suggest that all patients coming to hospital with obstruction within 24 hours after onset of symptoms should be subjected to immediate operation

As in other ailments patients in advanced years exhibit an increa ed mortality McKittrick and Sarris found that the risk run by patients over 60 with acute intestinal obstruction was 64 per cent for patients 70 or over the mortality was 75 per cent In our own cases of obstruction Dennis and Brown (1942) observed no increase of mortality with increasing years Obstructed patients, without abdominal scars from previous operations, run a greater risk apparently than patients operated upon previously—owing no doubt to the greater confusion hedging about the diagnostic problem

There are a number of obstructions such as congenital atresia of the new born volvulus mesenteric thrombosis, and the ileus of peritonitis which carry rather formidable risks

B SUGGESTIONS TO DECREASE MORTALITY

The following appear to be significant items re ponsible for the continuance of an unwarranted mortality in obstruction

1 Late diagnosis
2 Delay in ho pital occasioned by
   a) failure to recognize the presence of obstruction
   b) *improper identification* of the type of obstruction present
   c) treating patients by suction too long before recourse to operation
3 Failure to prepare patients adequately for operation
   a) inadequate water and electrolyte replacement
   b) inadequate replacement of blood volume losses in strangulating obstructions
4 Improper choice of therapeutic procedure
   a) employment of suction in presence of strict contraindication or too protracted u e of suction in patients presenting relative indications for its use
   b) poor choice of surgical procedure

In the review, covering the first seven-year period during which suction was employed in this clinic, the mortality concerned essentially (1) strangulating obstructions, comprised of the following items, a) strangulated incisional hernias, largely amongst obese, old people in whom correction of the defect, in the absence of obstruction, would have commanded great risks Of 12 such patients, 7 died, a mortality of 58 3 per cent for

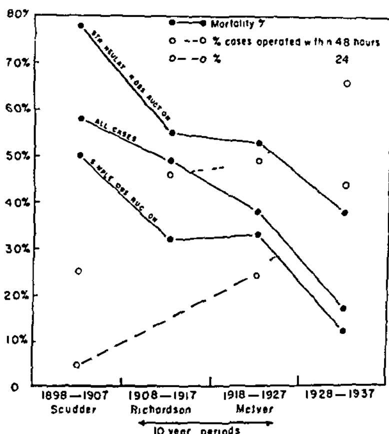


Fig 74—The mortality from acute intestinal obstruction at the Massachusetts General Hospital over a 40 year period The decline in mortality in the last decade is quite apparent (see also Table 25) (McKittrick and Sarris New Eng Med J 222 611 1940)

the group, b) strangulated non viable intussusception There were six deaths amongst 15 patients a mortality of 40 per cent Despite the continued eleventh hour arrival of some such patients, with adequate blood loss replacement and employment of the closed (aseptic) oblique end to end anastomosis, the accomplishment in this group has been considerably better recently, and c) treating patients conservatively who proved at autopsy to have strangulating obstruction and should have been operated upon In the group treated by suction alone there were 57 patients amongst which four deaths occurred Two of these deaths occurred in patients with strangulated bowel

In addition, there is the hazard of treating patients by conservative management (suction) too long When these patients come to operation later, the technical problem is far greater, occasionally, than it would have been, had operation been undertaken initially This increased hazard concerns essentially two things (1) distension, increased in amount, over that present initially, and (2) decreased breaking strength of the bowel On the gentlest manipulation the peritoneal coat tears and after days of obstruction, as was pointed out previously adhesive bands may become fused with the gut wall, such that cutting or freeing them or any manipulation directed at removing the obstruction may cause accidental opening of the bowel with spillage at the site of fusion of adhesive bands and bowel wall

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   b) improper identification of the type of obstruction present
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   a) inadequate water and electrolyte replacement
   b) inadequate replacement of blood volume losses in strangulating obstructions
4 Improper choice of therapeutic procedure
   a) employment of suction in presence of strict contraindication or too protracted use of suction in patients presenting relative indications for its use
   b) poor choice of surgical procedure

5 Faulty technical execution of surgical procedures, especially *failure to perform an aseptic operation, in which no suggestion or evidence of spillage of intestinal content occurs*
6 Uncontrollable Factors
 a) obstructions, inherently difficult to deal with, such as congenital intestinal atresia or strangulated incisional hernias in obese pa tients *with poor cardiac reserve*
 b) old age and its physical infirmities which contribute to operative mortality
 c) great *intestinal distension*
 d) strangulating obstructions

With reference to item "C," listed under Uncontrollable Factors, it is to be remembered that in every instance of intestinal obstruction at some stage, the distension was not great The error, therefore, in a sense is one which could be avoided granted, 1) early diagnosis and 2) successful ap plication of the correct therapeutic procedure Similarly with item "D," granted early diagnosis and early and technically correct execution of the proper operative procedure, the problem of strangulating obstruction should not be so formidable For, after all, with the single exception of mesenteric embolism or thrombosis, granted early operative release from the strangulating agent all forms of strangulating obstruction may be treated as instances of simple obstruction

Concentration of the responsibility for management of patients with acute intestinal obstruction, in the hands of a few persons of each hospital staff, would augment considerably the general accomplishment in the problem The important therapeutic problem in bowel obstruction is to achieve decompression before the ill effects of sustained increase in in traluminal pressure has impaired the viability of the bowel wall, causing increased capillary permeability A small group in each hospital, who set themselves the task of wrestling with the problem, would soon make every hospital staff obstruction minded

A better knowledge of the effects of obstruction, a more acute appre ciation of the criteria which permit timely recognition of the presence and identification of the type of obstruction, and, finally, a more discerning understanding of the limitations and virtues of the available remedial agents, together with a keener interest in the technique of carrying out therapeutic precepts with precision—these are the important items in the bowel obstruction problem

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PART IV

THE SPECIAL OBSTRUCTIONS

Chapter XI

CONGENITAL ATRESIA OF THE INTESTINE

A PATHOGENESIS

Frequency

This condition is relatively rare, occurring approximately once in every 20 000 infants In 1877, Theremin reported having found two cases over a period of eleven years among 116 451 children admitted to an institution for children in St Petersburg Ernst in 1916, reported the occurrence of two cases among 41,000 infants in Copenhagen In 1926 Shelden stated that among 6 000 autopsies performed at the Hospital for Sick Children in London since 1900 there were 26 instances of congenital atresia and stenosis In 1931, Webb and Wangensteen found mention of more than 500 cases of congenital atresia of the intestine in the literature There appears to be an equal distribution of the cases between the two sexes Denny and Sloan have recently described the occurrence of intestinal atresia in twins

B THEORIES OF ORIGIN

A large number of causes have been advanced to explain the occurrence of intestinal atresia The one that is given widest credence is that these areas of occlusion are due to persistence of epithelial buds in the intestine

In describing the development of the esophagus of the elasmobranch Balfour referred to it as a solid organ and pointed out that only later did it acquire a lumen Tandler has shown in human embryos between 30 and 60 days of age that the duodenum is solid and suggested that the atresia found in congenital occlusion of the intestine was due to failure of the bowel to acquire a lumen Kreuter who has also given the subject intense study in human embryos concurs in this opinion

Schridde examined the esophagus in a number of embryos and never observed a stage in which a lumen was not present Forssner who has been an ardent student of the matter, observed the presence of vacuoles in the esophagus and in the duodenum In the esophagus he found that the continuity of the lumen was not impaired by the presence of these vacuoles whereas in embryos of 16 mm the epithelium throughout the extent of the duodenum was occupied by large vacuoles He expressed the opinion that occurrence of atresia is due not to arrested development but to over development of the Mesenchym Zapfen or forerunners of the villi In embryos from 20 to 30 mm in size these grow into the bowel and extend into the lumen so far that a mesenchymal bridge or diaphragm is formed

Stenosis may at first result, to be transformed later into atresia Johnson studied the development of the intestine in the chick and found these vacuoles present in 16 mm embryos in the duodenum and jejunum The lumen of the lower jejunum and ileum was found to be pervious throughout its entire length

Theremin has been a strong advocate of the theory of fetal peritonitis as the etiological factor in the causation of intestinal atresia Bland Sutton stressed the occurrence of developmental abnormalities in the intestine at the sites of "embryologic events," pointing out the frequency of alterations at the duodenum, the duodeno-jejunal juncture, the ileum in the vicinity of Meckel's diverticulum and at the ileocecal region Fetal volvulus of the bowel has also been suggested (Kuliga), as has failure of development of the mesenteric vessels to a given area of the intestine (Wyss, Jaboulay) Among other causes that have been put forward, may be enumerated kinking of the bowel, especially at the duodeno jejunal juncture, fetal intussusception, strangulation through a mesenteric orifice, inflammation or ulceration of the intestinal mucosa, and hypertrophy of the valvulae conniventes, and pressure at the head of the pancreas (Spriggs) The frequent occurrence of prematurity as evidenced by body length or weight has been noted by Pehu and Auberge

Perhaps no one of these factors will adequately account for all cases of intestinal atresia but failure of a portion of the intestinal tract to acquire a normal lumen during its developmental period would appear to be the most plausible In 1 out of every 10 instances, some other significant embryologic defect is also present (Spriggs) Of these, imperforate anus is the most frequent, in the 24 cases of intestinal atresia recorded by Spriggs, this deformity was present 4 times Absence of some portion of the intestinal canal, congenital cystic kidneys, malformation of the extremities, and congenital heart disease are some of the developmental anomalies that occasionally accompany intestinal atresia

C PATHOLOGY

The most frequent site for the obstruction is in the lower ileum and jejunum, although it may be present at any point in the intestinal tract In the 392 cases collected by Davis and Poynter, the following tabulation gives the location of the atresia

TABLE XXVI —INCIDENCE OF SITES OF INTESTINAL ATRESIA

Duodenum above the papilla	59
Duodenum below the papilla	75
Jejunum	60
Ileum and cecum	101
Colon	39
Multiple areas	67

In the cases collected by Tandler, the occlusion was found to be present in the duodenum 33 times, in the jejunum and ileum 55 times, and in the colon 6 times Vallois and his associates, in a collection of 224 cases, gave the following percentage of occurrence duodenum, 33 per cent, jejunum,

and ileum in 53 per cent, and, in the large intestine, in 10 per cent of instances Of the duodenal cases alone, Cordes, in a total of 57 cases, found the obstruction above the orifice of the common bile duct in 20, below in 13, and at the level of the duct in 2, the others were not classified In a more recent report of 113 cases by Garvin, the site of obstruction was described as above the papilla in 34, opposite the termination of the common bile duct in 19, below in 25, and at the duodenojejunal flexure in 19, while 16 remained unclassified

The obstruction is usually single, but in about 15 per cent there are multiple areas of atresia In the multiple cases, Davis and Poynter found,

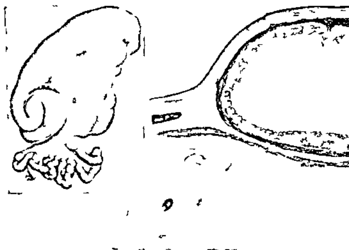


Fig 75—Multiple areas of constriction in atresia of the intestine of a newborn The histology of the atresic area is well illustrated (Erb Amer J Path 2 137 1926)

in slightly more than 50 per cent, from 2 to 9 occlusions in the jejunum and upper ileum In multiple constrictions, stenosis and atresia may co exist The point of obstruction may be narrow or moderately wide Above the level of obstruction, the bowel is usually distended in some instances so markedly that the pyloric ring is obliterated or rupture of the bowel may occur Hypertrophy of the intestinal wall above the obstruction occurs, regularly as shown in the accompanying photographs from case 1 in the series reported by Webb and Wangensteen Below the obstruction the bowel is constricted and often ribbon like especially in low obstructions The presence of bile in the contents of the lower bowel depends usually on the site of obstruction as related to the common bile duct In some cases, however bile tinged meconium has been reported to have been present in the colon with complete obstruction of the duodenum below the papilla of Vater (Cordes) For this occurrence the presence of an anomalous bile duct or the development of the atresia after the fifth fetal month at which time bile is normally present in the intestine has been offered in explanation

The degree of constriction may vary from stenosis to complete obstruc

tion, an interruption—a gap in the bowel with or without the absence of the corresponding mesenteric segment, may exist There may be a cord like structure connecting the segments of bowel, which may contain all the layers of the intestine, or its component parts may be unrecognizable The photograph of a section through the connecting structure from such a case shows that it is made up altogether of fibrous tissue (Fig 75) Sheldon reported a case in which microscopic section through the con necting band showed *all the normal intestinal layers to be present, with* the mucosa completely fused Absence of a segment of bowel has been reported by numerous authors Erb reported an instance of interruption of continuity of the jejunum, with isolation of a small segment, both ends of which were closed Thomas reported the complete absence of the duo denum, the ileum, and the greater portion of the colon The writer has observed a case in which there was not only interruption of continuity, but almost complete absence of mesentery

Spriggs collected cases from several of the hospital museums in Lon don and refers to the instance of an infant that had attained the age of 9 months with a septum like obstruction lying across the jejunum He also refers to the instance of a boy who attained the age of 19 years with partial atresia of the intestine Carling reported the case of a man aged 47 years, who had a stricture of the duodenum, apparently of congenital type, at the duodeno jejunal angle Judd and White reported 2 instances of obstruction of congenital origin at the duodeno jejunal angle in patients 19 years of age Cannon and Halpern described the instance of a child who had periodic attacks of obstruction who died at the age of 8 years with perforation of the stomach, a membranous septum exhibiting only a small iris like aperture at about the level of the papilla of Vater was re sponsible Touroff and Sussman have reported recently an instance of pre pyloric membranous obstruction in an infant for which division of the septum and pyloroplasty were performed successfully

D CLINICAL FEATURES

After birth the infant ordinarily takes its first feedings well In atresia of the lower ileum regurgitation of ingested milk may not occur for several hours The bowels may move but there is usually no suggestion of bile pigment in the movement Regurgitation occurs, as a rule, soon after the first nursing in duodenal atresia The inception of vomiting is related usually to the location of the obstruction but there is, however, no absolute correlation Helmholtz and Farr and Fries assert that they have observed cases in which no vomiting occurred up to the time of death The meconium may or may not be tinged by the presence of bile pigment de pending upon the location of the atresia Bile is formed in the liver between the third and fourth months and finds its way into the intestine usually at the beginning of the fifth month Intestinal atresia, if present, is ordinarily well developed at this time and the bile pigment will not find its way into the lower reaches of the intestine In stenosis without complete atresia bile may find its way into the lower segments of the intestine Cordes states that bile tinged meconium has been observed in complete atresia of the bowel below the duodenal papilla Such an occurrence would appear to

be unlikely and would demand for a satisfactory explanation the presence of an anomalous insertion of the bile duct below the atresic area or development of the atresia in the bowel after the fifth fetal month following the appearance of bile in the intestine

After a few days jaundice will occur if intestinal occlusion is below the ampullary termination of the common bile duct This occurrence is of little value in the recognition of the disorder because of the frequency with which jaundice occurs in the new born As a result of loss of fluid and lack of absorption, dehydration is frequently evidenced by anemia poor tissue turgor, depression of the fontanel loss in weight, and fever

The grade of distension present is determined by the duration of the obstruction and its location When the obstruction is low, the abdominal distension may be considerable

Duodenal occlusions are accompanied only by distension of the stomach and the proximal duodenum The absence of bacteria in the bowel distal to the obstruction and the exclusion of swallowed air from the oral source preclude the appearance of gas in the intestine beyond the site of occlusion (Fig 76)



Fig 76—Duodenal atresia No air is visualized in the intestinal canal (Amer J Dis Child 41 262 1931)

E DIAGNOSIS

The expulsion of meconium untinged by the presence of bile pigment in a new born when associated with vomiting is presumptive evidence of the existence of intestinal atresia In supra papillary occlusions the vomitus will fail to exhibit bile and the meconium is green When the occlusion is at the papilla neither vomitus nor stool may contain bile Farber (1933) has stressed the finding of cornified epithelium in the meconium as being significant of a bowel whose continuity is intact Conversely, the absence of cornified epithelium (swallowed vernix caseosa) in the presence of obstruction suggests atresia of the bowel That the fetus swallows amniotic fluid has been demonstrated nicely by Becker Windle and their associates (1940)

Roentgen examination affords reliable evidence *A film of the* abdomen demonstrates the presence of intestinal distension The location of the distended coils of bowel gives also some information as to the level of the obstruction It should be recalled here that whereas in the adult mere visualization of gas in the small intestine on the x ray film is significant of intestinal stasis that gas is normally *visualized in the small* intestine of children up until past two years of age The occurrence of bowel dis

tion, an interruption—a gap in the bowel with or without the absence of the corresponding mesenteric segment, may exist There may be a cord like structure connecting the segments of bowel, which may contain all the layers of the intestine, or its component parts may be unrecognizable The *photograph of a section through the connecting structure* from such a case shows that it is made up altogether of fibrous tissue (Fig 75) Sheldon reported a case in which microscopic section through the connecting band showed all the normal intestinal layers to be present, with the mucosa completely fused Absence of a segment of bowel has been reported by numerous authors Erb reported an instance of interruption of continuity of the jejunum, with isolation of a small segment, both ends of which were closed Thomas reported the complete absence of the duodenum, the ileum, and the greater portion of the colon The writer has observed a case in which there was not only interruption of continuity, but almost complete absence of mesentery

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of obstruction usually from birth but frequently months go by before the presence of a mechanical occlusion forcibly impresses itself upon the attendants, some such cases even reach maturity As is pointed out in the section on strictures, a stenosis in the small bowel is often tolerated for long intervals, without symptoms The presence of a diaphragm-like stenosis can occasionally be recognized at operation Whenever obstruction occurs in the new born, intestinal atresia or one of its variants, viz, stenosis or a diaphragm in the bowel are always to be thought of The determination of what type of obstruction is present must occasionally be left to operation (Cole)

G PROGNOSIS

The outlook is necessarily poor Many pediatrists and surgeons have looked upon the condition as irremediable Most untreated cases die within a week A few infants with total occlusion have survived for a surprisingly long time Theremin described an infant with complete atresia of the lower ileum that lived three weeks Cases exhibiting intestinal stenosis as those of Carling Judd and White, and Cannon and Halpern referred to above may grow into childhood or adulthood manifesting intermittently signs of interference with the continuity of the bowel

H TREATMENT

In dealing with simple interruption of the continuity of the intestine in older children and adults the surgeon permits himself to be guided entirely in the choice of operative procedure by the condition of the patient When the obstruction is late, an operation of necessity viz decompression of the bowel by enterostomy is done, whereas operations of election in which the continuity of the intestine is restored are reserved for the good risk patient In conformity with this principle it would appear that the operation of least risk for the infant with intestinal atresia would be the performance of enterostomy

It is a significant fact that all of the patients in whom enterostomy has been done have died In 1902 Braun collected nineteen cases of congenital atresia of the intestine in which enterostomy had been done, with a lethal outcome in every instance Tischendorf operating on an infant 6 days old found an obstruction 25 centimeters above the ileocecal valve The child survived enterostomy for 15 days an occurrence which led Braun to suggest that this was the operation of choice for all cases of low atresia Braun made his report, however, nine years before the first successful operation for intestinal atresia

In 1911, Fockens of Rotterdam reported the first successful operative intervention for the relief of this condition The case concerned an infant aged 7 days with atresia at the juncture of the middle and lower thirds of the small intestine There was a defect about 4 centimeters in length in which the intestine was absent the proximal and distal ends of the bowel being closed A side to side anastomosis was made with recovery of the patient When Fockens made his report five months later, the child was well

tension as visualized on the x-ray film and the audition of loud intestinal noises on auscultation of the abdomen are very suggestive of the presence of intestinal atresia. Gaseous distension of the stomach and first portion of the duodenum, without visible gas on the films throughout the remainder of the abdomen, suggests duodenal atresia. For, if the infant has not swallowed air, no gas will be visualized *in the intestine on the x ray film*. In duodenal occlusions, splashing borborygmi are usually absent.

Whereas the administration of barium to detect the presence of acute *intestinal obstruction is to be condemned because it often contributes* to delay in diagnosis, in the recognition of intestinal atresia, the method has real worth. The oral administration of a thin barium mixture by mouth *will quickly* indicate whether the atresia is in the duodenum and the instillation of barium into the rectum will exclude a colonic occlusion. The information gained by these examinations does not consume much time and affords often reliable information as to the location of the obstruction and in some measure aids the surgeon in determining whether multiple atresic areas separated from one another are present. Any information that enables the surgeon to treat this most hazardous affliction more intelligently and with expedition at operation is well worth obtaining. *Yet, if the diagnosis can be made without the administration of barium, it* should be omitted. If barium is administered by mouth, the stomach should be washed out carefully, before an anesthetic is administered.

F DIFFERENTIAL DIAGNOSIS

The obstructive features of the malady are not easily mistaken. Anomalies of development of the mesentery, such as imperfect rotation and mesenteric fixation may give rise to volvulus, adhesive bands, a Meckel's diverticulum and imperforate anus may also cause intestinal obstruction in the new born. Atresia of the pelvic colon may be confused with imperforation of the rectum. The latter is easily excluded by inspection of the anal dimple or by passing a small bougie in case of doubt. The expulsion of feces obviously excludes imperforate anus. The absence of bile in the meconium immediately gives reliable aid in differentiating intestinal atresia from herniation of the bowel through an aperture in the mesentery as well as from congenital volvulus. In both these latter conditions, there is present almost uniformly moderate tenderness and rigidity of the abdominal *wall incident to the presence of strangulated and infarcted bowel*. A flaccid non-tender abdomen attends intestinal atresia, even though considerable distention be present.

The time relation *serves to differentiate congenital hypertrophic pyloric* stenosis from atresia of the duodenum. The symptoms of the latter are initiated soon after birth. Whereas the former rarely gives symptoms before the second or third week. Pyloric *stenosis affects the male infant* fifty times more frequently than the female; intestinal atresia affects the male and female infant with equal frequency.

Incomplete atresia or so called congenital *intestinal stenosis may* be recognized by the identification of ingested food in the stool. This condition is rarer than complete atresia. Infants with stenosis have symptoms

the small intestine in the infant unless the external vent be made in the very terminal ileum, is doomed to failure from the start Birgfeld reported the instance of an infant, aged 50 hours, on whom he performed a side to side anastomosis for atresia of the upper part of the ileum An enterostomy was added also Although the fistula closed in three weeks vomiting and distension recurred, necessitating a second operation at 4

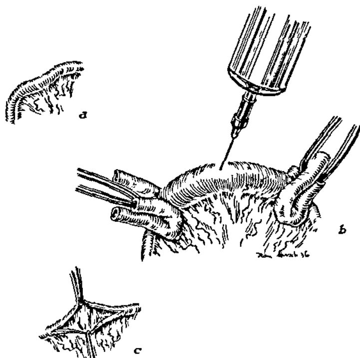


Fig 78—Method to increase the diameter of the lumen of the bowel to facilitate anastomosis in intestinal atresia (a) The actual size of the bowel distal to the atresic obstruction (b) Distension of its lumen with air (c) Preservation of some of the increased diameter after incision The ana tomosis should be made with a single row of interrupted sutures of fine silk or with a single running Connell suture (Amer J Dis Child 41 26? 1931)

weeks of age following which the patient died When the atresia is in the colon, a colostomy would appear to be the operation of choice

Two factors contribute to the extreme difficulty and hazard in the surgical treatment of congenital intestinal atresia A new born infant with intestinal obstruction is a poor operative risk these patients tolerate the loss of vital fluids poorly, and, the small lumen of the bowel into which fluid from the proximal portions of the intestine has never made its entry, presents an exceedingly difficult technical problem The performance of an intestinal anastomosis on such a bowel with preservation of an intestinal lumen appears to be an impossible task frequently (Fig 78)

The writer was privileged to operate upon two infants with intestinal atresia, both of whom died These operations were done more than ten years ago In both instances an entero anastomosis was made, in the first

In 1916, Ernst performed a successful duodenojejunostomy for duodenal atresia in an infant, aged 11 days Loitman referred to two other cases of high atresia in which gastro jejunostomy was successfully performed for congenital occlusion, both patients being well some time later Richter recorded the instance of an infant, aged 4 days, with duodenojejunal atresia on whom he performed a successful posterior gastrojejunostomy A volvulus of the ileum was reduced successfully also In 1927 Weeks and Delprat reported a successful gastro jejunostomy, performed in 1916, for congenital occlusion of the third portion of the duodenum in an infant, aged 6 days In the discussion of MacLennan's paper on acute intestinal obstruction in infancy and childhood, Cameron mentioned that a patient with congenital duodenal atresia had been operated upon by Steward, with complete recovery Sweet and Robertson reported a successful issue after two operations on an infant for duodenal atresia The infant was first operated upon on the ninth day of life a gastrojejunostomy being performed Twelve days later, because of continued vomiting, a second operation was done, uniting the anterior aspect of the second portion of the duodenum to the jejunum distal to the *initial anastomosis* Four months later, the child was in good health Demmer recently reported a successful outcome in a case similar to that of Fockens He resected the vestige of the terminal ileum and cecum and anastomosed the proximal ileum to the cecum Smith did a low enterostomy on an infant with stenosis of the ileum that survived for 41 days The Corkhills report another operative success after anastomosis of the ileum to the sigmoid flexure in an atresic ileum with concomitant imperfect rotation



Fig 77—Congenital duodenal stenosis relieved by duodeno-jejunostomy

Miller has reviewed, recently, (1939) the literature of the results of surgical management of congenital intestinal atresia Additional successes are being reported constantly Donovan has had several successes In their recent monograph, Ladd and Gross (1941) state that out of 52 patients with intestinal atresia, at the Children s Hospital in Boston there were 7 recoveries There were 22 additional cases of congenital intestinal stenosis with 10 recoveries (See also *extrinsic stenosis* Chapter XX)

These and other operative triumphs probably now two dozen or more attest the fact that intestinal atresia is not irremediable They indicate further that, an anastomotic procedure is the only operation that holds any promise of success The establishment of a complete external fistula of

gut for this suture because it is more easily drawn through the thin bowel without damage to the wall Silk sutures resist digestion also and afford firmer union The open anastomosis is to be preferred to the closed in that no cuff need be cut away

Duodeno jejunostomy is a better operation than gastrojejunostomy for duodenal astresia, as Ladd points out Further, gastrojejunostomy may be followed by a stomal ulcer, years after its performance

It is essential to administer saline solution subcutaneously to infants who have not been able to utilize ingested fluids They must also be kept adequately warm by the external application of heat The performance of the operation with dispatch is important Everything must be in readiness before the operation is begun Infiltration of the abdominal wall with procaine hydrochloride will suffice usually, re enforcement with light ether anesthesia may be necessary It is a good plan to attach two clamps to the skin on both sides of the wound If there is any straining during the exploration, the skin may be pulled together across the wound and a threatened evisceration is thus easily obviated

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infant, the anastomosis was a technical failure, in the second, a satisfactory anastomosis was made by *inflating the collapsed bowel by the injection of air into its lumen before incising it* (Fig 78) Even when incised, the bowel preserved an increased lumen permitting of an easy anastomosis The infant died unfortunately of hemorrhage An intact functioning anastomosis was demonstrated by necropsy (Fig 79) The administration of Vitamin K, to diminish the hazards of the hemorrhagic diathesis in in-

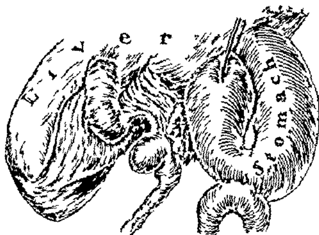


Fig 79—*Gastro-jejunostomy for duodenal atresia* There is complete interruption of the continuity of the gastro intestinal canal at the points of juncture of the first and second portions of the duodenum The common bile duct emptied into the summit of the second portion *Pancreatic tissue was directly* interposed between the two closed ends Drawing made of the anastomosis at postmortem (Amer J Dis Child 41 262 1931)

fants with atresia of the intestine would undoubtedly circumvent this difficulty Vitamin K administration should be made *in all such instances* A successful duodeno jejunostomy has been done in a third infant with stenosis of the third portion of the duodenum (Fig 77) The operative technical problem however, is not as great in infants where the bowel distal to the obstruction has been *distended by intestinal secretions* Ladd has had several successes with this type of obstruction in the newborn

In effecting the anastomosis between the distended proximal and distal collapsed segment, *it is also a good plan to deflate the proximal distended* bowel by milking out its content between the fingers or aspirating its content with a fine hypodermic needle after engaging the segment in a soft rubber covered intestinal clamp (Figs 47 and 48)

This *procedure not only* does away with soiling, but also permits the thinned out wall of the bowel to shrink Only fine silk is to be employed in the suture A single running suture after the Connell method will usually give a satisfactory anastomosis *A few additional interrupted sutures* will give added security and adequate strength Silk is to be preferred to cat-

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The rectum, he states, may be looked upon as having developed from two parts. At one stage of human development (embryo of 12 somites) the rectum ends by opening into the cloaca in its upper part in the neighborhood of the genital ducts. This is the older portion of the rectum; imperforation usually concerns the new part that runs to the anal canal.

This anomaly of development is not infrequently associated with other embryologic defects. Hypospadias, bicornuate uterus, deformities of the external ear and external auditory canal, cardiac anomalies, abnormalities of the spine and of the lower extremities, especially clubfoot, are some of the most commonly observed defects found associated with imperforate anus. Atresia of the intestinal canal at a higher level is only rarely observed as a complicating feature.

C PATHOLOGY

Two types of imperforation are recognized, viz., with or without abnormal fistulous communication of the terminal bowel. Stieda's classification on this basis is widely accepted. Stieda made a separate division of external fistulous termination of the bowel, believing that these represented pathological abnormalities as differentiated from inhibition of normal development. Most authorities who accept his classification see no need for this differentiation.

TABLE XXVII.—CLASSIFICATION OF IMPERFORATION

I Simple atresia
- (1) atresia of the anal canal
- (2) rectal atresia
- (3) atresia of the anal canal and rectum

II Atresia of the anal canal or rectum with fistulous communication

(1) vaginal		female
(2) external	vaginal commissure	female
	perineal	male
	scrotal	male
	suburethral	male
(3) urethral		male
(4) vesical		male

Ziemendorff collected from the literature 114 cases of imperforate anus between the years 1893 and 1909. These divided themselves as follows with reference to Stieda's table.

TABLE XXVIII.—INCIDENCE OF VARIOUS TYPES OF IMPERFORATION

		Cases	Per Cent	
Type I	(1) anal atresia	28	24.6	52 cases 45.6 per cent
	(2) rectal atresia	16	14	
	(3) anal and rectal atresia	8	7	
Type II	(1) vaginal fistula	38	33.3	62 cases 54.4 per cent
	(2) urethral fistula	11	9.6	
	(3) vesical fistula	9	7.9	
	(4) external fistula	4	3.5	

Among 100 cases of imperforations collected by Curling (1860) in

Chapter XII

IMPERFORATE ANUS

A PATHOGENESIS

Frequency

Atresia of the anal canal or the lower portion of the rectum occurs about *once in every 5000 births* Whereas a few smaller series of cases show the disease to be more frequent in males than females, larger compilations indicate that the incidence is about equally divided between the sexes In 272,611 births at the Paris Maternity Hospital, the New York Lying in Hospital, and the Manhattan Maternity Hospital, as reported by Tuttle, the incidence of imperforate anus was one in 5,652 cases

Heredity appears to play a role in some instances Anders refers to the following illustrative instances In 1885, Hadra reported a family in which six cases of imperforate anus were observed in several generations, in his text on surgery, Konig reported the instance of a boy whose two brothers and father were afflicted with the deformity, and Wirtza (1851), Anders states, observed the occurrence of the imperforate anus in three out of ten children in one family

B EMBRYOLOGY

The primitive gut develops from the entoderm ventral to the notochord and forms a tube which becomes suspended in the embryonic coelomic cavity by being pinched off from the parent entoderm The allantois develops from the ventral side of the caudal end of the primitive gut and becomes enclosed in the umbilical cord The portion of the gut caudal to the allantois becomes dilated and forms the cloaca which is, at first, a blind sac separated from the outside by a thin membrane The cloaca then splits into two portions—a dorsal from which the rectum develops, and a *ventral from which develops the urogenital sinus* When the future rectum reaches the perineal depression, it comes in contact with the closed ectodermal cloacal membrane The dorsal migration of the rectum signals segregation of bladder and rectum which become separated by the urorectal septum In the foetus, at the seventh week, the vestibular folds appear on either side of the perineal fissure, whose union with the urorectal septum separates the urinary and genital orifices from that of the bowel Imperfect closure means a persistent cloacal anus in which the discharges of the bowel may be dumped into the bladder urethra, or vagina The anal plug in the cloacal membrane breaks down at the commencement of the eighth week forming the permanent anus (Keith) This process failing to occur, imperforate anus results

Wood Jones points out that the malformation in imperforation in the majority of instances concerns the post allantoic gut, the portion of the hind gut caudal to the allantois that grows down and joins the anal plate

present in 60 per cent of the specimens In the male, he found that the most frequent malformation was termination of the rectum in the urethra in the female, vaginal termination of the rectum occurred most frequently The accompanying table from Keith's splendid article on malformation of the hind end of the body indicates the frequency of each type and the site of abnormality in the sexes

The nature of the occlusion in anal atresia may be in the form of a thin diaphragm or the entire canal may be impervious Stenosis without actual imperforation may go unrecognized till constipation and accumulation of fecal masses in the colon direct attention to their presence Vernon David and Brenneman have each reported instances of this kind the patients presenting themselves with megacolon In rectal atresia the anal aperture may or may not be present The rectum ends as a blind sac at a variable distance from the perineum Fistulous communication of the rectum with the uterus has been reported (Anders) Due to the early segregation of urinary and genital passages in the female vesical and urethral terminations of the rectum are unknown in that sex Communications with the bladder or prostatic urethra in the male are usually established by a narrow tract In the instances in which a urethral communication was present Keith found that in 4 cases, the orifice was between 2 and 3 mm in diameter in 5 instances the orifice measured between 1 and 2 mm in 6 it was merely large enough to admit a bristle and therefore too small to allow the passage of feces In all instances Keith found the orifice of the tract provided with a sphincter In the bladder terminations however a cloacal type of communication is occasionally observed Vaginal communication in the experience of the writer has usually been in the posterior commissure (Fig 81)

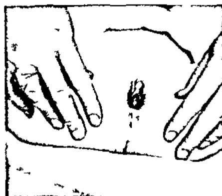


Fig 81 —Imperforate anus with termination of the rectum in the posterior commissure of the vagina

In instances of imperforation with a fistulous communication obstruction to the outlet of feces does not at first obtain, later when the infant's stool attains a more solid form however the fistulous tract is inadequate to permit of normal defecations In consequence large fecal masses may accumulate in the colon Dilatation and enormous hypertrophy of the bowel wall as occurs in megacolon is not unusual This occurrence is especially likely with vaginal external fistulous terminations of the rectum (Fig 82) Such fecal accumulations may lead to acute bowel obstructions and even perforation of the proximally distended cecum

When the fistulous tract terminates in the urinary passages death from kidney infection usually supervenes before fecal obstruction occurs

57 per cent of instances simple atresia was present, in the other 43 instances, some fistulous communication existed

Sir Arthur Keith found in examining the specimens of the London hospitals and museums that fistulous communications were more frequent than simple atresia (Fig 80) Such fistulous termination of the bowel was

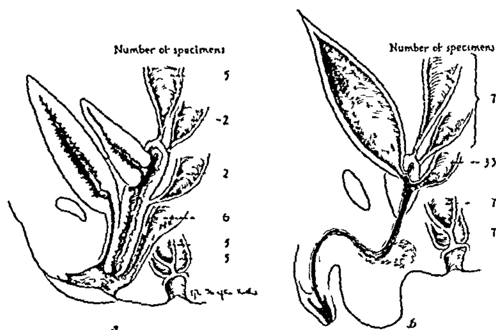


Fig 80—Frequency of the various types of imperforate anus (a) In the female (b) In the male (After Keith Brit M J 2 1736 1908)

TABLE XXIX—SPECIMENS OF MALFORMATION OF THE RECTUM IN LONDON MUSEUMS (Keith 1908)

Groups	In Museum of Royal College Surgeons	In Museums of Metropolitan Medical Schools	Total
A Males			
1 Rectum opening in urethra	7	26	33
2 Rectum ending as a cord at or above base of prostate	0	7	[illegible]
Rectum ending as cord at site of proctodaeum	1	6	7
B Females			
1 Rectum ending in vulva or vagina	1	5	6
2 Rectum ending as a cord at upper fornix of vagina	0	5	5
3 Rectum ending as cord at upper fornix of vagina	0	3	3
4 Rectum ending as cord on vagina below upper fornix	0	2	2
5 Rectum ending blindly or as cord at side of proctodaeum	3	7	10
	12	61	73

F DIAGNOSIS

No type of bowel obstruction is more easily recognized Acquaintance with its occurrence serves to identify it The recognition of the type of imperforation present is also usually easily made The extent of the impervious bowel in simple atresia can not be made out, however, by the ordinary criteria of physical examination A number of authors have

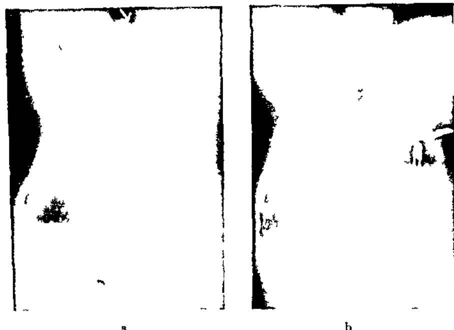


Fig 83—Method of demonstrating the extent of imperforation (a) In this instance only the anal plate remains imperforate (b) Atresia of the anal canal and rectum Holding the infant up side down permits the gas in the bowel to mount to the highest point (Ann Surg 92 80 1930)

emphasized that abnormal narrowness of the inter ischial tuberosity measurement is indicative of an extra pelvic rectum This information, however may be equivocal and is not to be relied upon The maneuveur suggested by Wangensteen and Rice (1930) is of some help in this matter When an x ray film is made of the infant s abdomen and pelvis in the inverted posture (Fig 83) the height to which gas ascends in the pelvic colon and rectum serves to determine the extent of the imperforation Isolated atresia of the colon as reported by Hamilton should be easily detected with the aid of this criterion (Fig 84) Should atresia of the small intestine or proximal colon coexist with imperforation of the hind gut no gaseous shadow would be found in the pelvis when the x ray film was taken in the inverted posture inasmuch as the oral source of gas would be shut off proximally The distension of coils of small intestine would establish the coincident presence of intestinal atresia It is to be remembered however that gas is normally visualized on an x ray film of the infant s abdomen up to about three years of age In attempting to determine the

Bodenhammer records some very extraordinary cases of imperforation so fantastic that the most credulous would be rather skeptical of their occurrence One of these, a girl of fourteen years, first reported by Baux (Jour de Med de Paris T 8, p 59) "had neither an anal, genital nor urinary opening There was not the least appearance of these apertures, the skin being smoothly continued over the region naturally occupied by them, as on other parts of the body At the end of every third day, she experienced considerable pain around the umbilicus, and immediately after would eject fecal matter by vomiting Her urine was entirely voided by the nipples every three or four hours This girl was well formed in other respects and of a very agreeable person She had a good appetite, slept well, and had general good health"



FIG 82—Fecal impaction in the rectum and pelvic colon in imperforate anus with termination of the rectum in the vagina The fecal mass is responsible for the opaque shadow In the ascending colon and hepatic flexure the less dense collection of feces gives a speckled appearance

D CLINICAL FEATURES

Here inspection of the perineum in the new born serves to detect the presence of anal atresia When the anal opening is normal recognition of the existence of imperforation is usually made when an attempt is made to insert a clinical thermometer into the rectum In infants born outside of hospitals, the presence of the deformity is often later announced in failure of the infant to expel meconium In those instances where an internal fistulous communication exists with the bladder or urethra, discoloration of the urine with feces heralds its presence In vesical termination of the rectum, the entire voided urine is tinged with meconium, and constant admixture of feces with the urine is the rule When the communication is with the urethra, the first urine voided will be discolored, toward the end of micturition the urine will be quite clear The vaginal termination of the rectum in the female infant is usually noted when defecation occurs as the infant's diaper is changed The absence of the normal outlet and the spontaneous expulsion of meconium serve to identify it

A child with imperforate anus takes its feedings in the normal manner for the first 24 hours before regurgitation commences The abdomen only gradually distends Absence of bowel movements or admixture of feces with the urine usually calls attention to the disorder before symptoms manifest the presence of the abnormality

rectum in the bladder or urethra unless relieved is followed by early death from pyelonephritis A few exceptions are found reported in the literature Page records the instance of a man of fifty four in whom an unsuccessful attempt was made shortly after birth to establish the normal termination of the rectum With the exception of a little fluid that drained away from the narrow sinus leading to the anal dimple that persisted after the early attempt at proctoplasty, *he discharged all his feces through the urethra* At the age of ten, an incision had been made in the patient's urethra to remove lumps of feces that blocked its lumen Page relates that the patient spent one and one half hours daily milking feces through the urethra At operation Page found the rectum to terminate by a fistulous tract in the urethra in front of the scrotum He merely disconnected the communication and sutured the fistulous termination of the rectum in the perineum The patient enjoyed such comfort after this procedure that he would not permit of the atresic rectum being brought down through the anal plate Undoubtedly however a communication with the anterior urethra as in Page s case, is better tolerated from the standpoint of kidney infection than the usual tract that ends in the prostatic urethra

Kelsey reports the instance of a man of twenty four years with anal atresia and vesical termination of the rectum He had a perineal stricture from an attempt made in infancy to bring the bowel down Some of his urine came out through the opening established in the perineum and some of the feces continued to be discharged from the bladder with the urine Kelsey *states that the man had gone as long as three months* without an evacuation and had then filled two chamber utensils with solid matter

G TREATMENT

Early establishment of external communication of the terminal bowel is indicated in complete atresia of the anal canal or rectum When steno is *alone* is present dilatation with bougies or the little finger well lubricated suffices In external fistulous termination of the rectum in the male and vaginal communication in the female no indication for immediate operative intervention usually exists In such cases the operation may well be deferred until a later period when transference of the lower bowel between the fibers of the external sphincter of the anal canal can be made with greater safety and more precision If the termination is stenotic it should be dilated When internal fistulous communication with the urinary passages exists the establishment of the normal termination of the bowel and severance of the abnormal communication are necessary to divert the fecal stream because of danger of urinary infection That instances of this sort may reach mature age despite the persistence *of such abnormal communication* is demonstrated from time to time

In those instances of simple atresia in which a diaphragm like septum is present mere slit of the anal skin and dilatation with a hemostat is all that is necessary Subsequent occasional dilatation with bougies may be required In all other instances of anal or rectal atresia a perineal dissection should be made In those instances where the lower portion of the rectum as well as the anal canal is atresic the operative approach is frequently difficult and uncertain The presence or absence of the anal

extent of the imperforation by the x ray maneuver described herein (upside-down position), it is obvious that some time must elapse after birth, before enough swallowed air makes its way to the lower reaches of the intestinal canal Paine and Nessa (1942) observed that, in the normal infant, gas can be observed in the upside down position on the roentgen film usually within 4 to 6 hours after birth In the infant with imperforate anus, obviously because of the presence of larger amounts of meconium in the distal colon, the transit of gas to the most distal end of the intestinal canal may take a little longer

In stenosis of the anal outlet without complete atresia, gas and meconium may escape when an attempt is made to pass a bougie into the rectum Vaginal external fistulous and urinary tract terminations of the rectum are recognized by careful inspection of the perineum and observation of the urine stream during micturition In the presence of a bristle like communication between prostatic urethra and rectum, admixture of feces with the urine may not be observed

F PROGNOSIS

In simple occlusion of the hind gut without fistulous communication, prolonged survival without the establishment of an external opening is impossible In the older literature one may find mention of instances in which such cases survived into childhood or adolescence, vomiting feces periodically In the absence of some fistulous orifice for gas or feces unless an outlet is afforded for their escape, death usually results within the first week of life and often from rupture of the distended colon Survival into the third week of life is occasionally noted Cripps refers to the instance of a well nourished girl, reported by Mercier, who had attained the age of thirteen years, vomiting fecal matter every fourth or fifth day However, such phenomenal instances appear to be no longer extant Patients with vaginal termination of the bowel usually present themselves when "diaper broke" for the relief of rectal stricture or incontinence Brenner refers to an instance reported by Morgagni in which a woman had borne several children and attained the mature age of 100 years without the existence of the defect having been brought to the attention of her husband and children In the male fistulous termination of the



Fig 54—Skiagram of an infant with atresia of the colon This condition is not to be confused with imperforation of the rectum (Bowers and Cook Arch Surg 34 868 1937)

bowel A two prong towel clip may be employed to lift the coccyx to give needed exposure Matas states that no hesitancy need be felt in sacrificing the coccyx and lower sacral segments, which he cuts away with scissors It is not necessary to do this very often, however A midline incision causes less bleeding and avoids unnecessary injury to the fibres of the levator ani

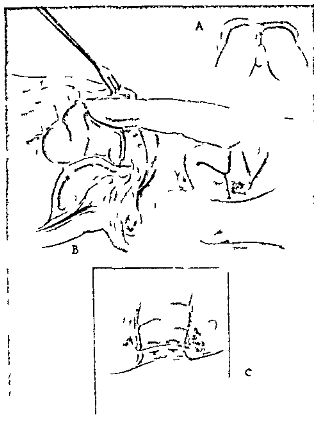


FIG 85—Operative correction of imperforation of the anal canal and rectum A The position of the infant on the operating table and the incision B The usual site of occlusion when the rectum is imperforate The coccyx is elevated with a small cat s paw retractor and the distended bowel is identified C David s suggestion of inverting the skin to meet the rectal mucosa to insure a dry anal canal

muscle When the peritoneum is encountered and the bowel has still not been reached Matas points out rightfully that the suggestion of Stromeyer to open the peritoneum and pull the bowel down is to be preferred to colostomy The writer however has not found it necessary to open the peritoneum often to tap the ballooned rectum When interpretation of the x ray films indicates that a pelvic colon is present, the bowel can be reached with greater safety to the infant from the perineum than by colostomy

orifice gives no indication as to the condition of the rectum and the extent of the atresia

In all cases of anal atresia and in the majority of instances in which the rectum is atresic, the bowel can be reached from the perineum. As one examines the literature of operations for imperforate anus, he is impressed by the frequency with which colostomy is performed when the bowel can not be reached with ease from the perineum. Clogg recommends the immediate performance of colostomy without an attempt at perineal dissection. It is important to perform proctoplasty rather than colostomy wherever feasible because of the lesser risk of the perineal operation. Sir Arthur Keith says that in 95 per cent of instances the atresic bowel can be reached from the perineal route. Cripps, who had considerable experience in operating for imperforate anus states that he never had occasion to perform a primary colostomy. Ashhurst believes that only in unusual instances is it necessary to perform colostomy to decompress the obstructed bowel. In every instance in which an x ray film taken in the inverted posture demonstrates the presence of a gas filled pelvic colon, the bowel can probably be reached from the perineum. A part of the difficulty in the treatment of imperforate anus and rectum arises from the idea that if the gut does not reach the anal plate, it may terminate anywhere. As Wood Jones has pointed out, however, imperforation involves almost invariably the post-allantoic gut and the segment of bowel concerned lies below Houston's upper fold of the rectum, except in those rare instances where a concomitant atresia of the colon also is present. The evidence, furnished by x-ray films of the extent of the atresic area, serves to lend encouragement and assurance that persistence will reward the surgeon's efforts when a tedious and seemingly unsuccessful approach from beneath prompts him to open the abdomen and perform colostomy.

If colostomy is deemed necessary, it is a good plan to note the configuration of the colon on the x ray film from the distribution of the gaseous shadows. The sigmoid flexure is frequently more medial than is commonly suspected. The writer once saw the catheter in the left ureter at necropsy after supposed colostomy performed for imperforation. Ritchie has carried out successfully in 2 instances a combined abdomino-perineal approach. The pelvic colon is opened suprapubically and a curved hemostat is pushed through this colotomy opening into the distal segment. This maneuver serves to indicate where the rectum may be found and opened in the perineum. It would appear that this procedure presents a great increase in risk over proctoplasty, because of the hazard of infection.

Technique of Proctoplasty

The infant should be placed prone on the operating table, the buttocks being somewhat elevated by a small pillow placed beneath the lower abdomen (Fig 85). This position affords much better exposure than the perineal lithotomy position. Very light ether is the anesthetic of choice. Straining on the part of the infant facilitates finding the distended rectum. A midline incision from the coccyx through the posterior margin of the external sphincter affords usually immediate access to the distended proximal

The vaginal type of fistulous termination is so short that it may be dilated successfully to facilitate extrusion of impacted feces Whenever a fecal impaction is present in the bowel, it should be evacuated before an attempt is made to establish a functional termination The writer prefers to deviate the fecal stream by colostomy before attacking vaginal termination of the rectum through the perineum Stone, however states that he has been able to secure satisfactory closure of the recto vaginal fistula and proper anchorage of the rectum by primary perineal dissection A longitudinal incision in the posterior wall of the vagina will usually permit of mobilization of the bowel The rectum is then pulled through a small incision in the anal dimple and attached to the skin The surgeon must be careful in mobilizing the rectum to preserve an adequate blood supply The operation is carried out most easily usually in the lithotomy position Gersuny advocated twisting the rectum somewhat to insure better continence The posterior vaginal wall is then repaired In external communications in the male, the approach is best made from behind the posterior margin of the anal plate the bowel being brought down as in the operation for simple atresia The fistulous tract extending anteriorly need only be severed no necessity existing usually for dissecting it out



Fig 86—Varco glass rectal dilator for treatment of stenosis after proctoplasty for imperforation of the anal canal and rectum A glass blower can make them readily of varying sizes The length of the dilator illustrated here is 4 cms and its width at the bulbous portion 2 cms and at the neck 1 cms These should be available in graduated sizes

Steudel reports the instance of a male infant with an external type of fistulous communication but which communicated with the urethra in front of the scrotum as in Page s case Steudel states that two years after transference of the outlet of the bowel to the anal plate the patient could control a diarrheal stool

It is to be emphasized that the treatment of imperforation does not end with the establishment of a perineal opening of the bowel Unless the rectum is brought down to the anal margin, stricture formation is almost certain to occur Walford reports the instance of a boy, aged seventeen, who died of perforation of the bowel consequent upon fecal impaction Edington records the instance of an infant of two days with a scrotal fistulous termination of the rectum in which he cut across the scrotal tunnel and brought the rectum in communication with the anal opening Edington subsequently learned from the mother that the child had died of obstruction at eight months

When the rectum is not sutured to the anal margin before the infant leaves the hospital dilatation of the new opening should be begun The mother should be instructed to do it daily with a bougie or the little finger Harrison Cripps devised a little rubber nipple that was inserted daily into the rectum to obviate stenosis My associate Dr Richard L Varco devised the glass dilator shown in Fig 86 which has proved very satisfactory In instances which demonstrate a tendency to contracture of

In rectal atresia more often than in complete atresia of the anal canal, the surgeon will have to content himself with an operation of necessity, viz, insertion of a catheter into the bowel followed by dilatation of the tract after operation Later when conditions permit, an attempt to establish a better functioning anorectal canal by bringing the bowel to the skin can be made

Male infants with imperforate anus and urinary fistulous communication are not brought for surgical relief as early as a rule, as when simple atresia alone is present Often they do not present themselves for deviation of the fecal current before the second or third week of life Persistent or transient discoloration of the urine during micturition will usually distinguish whether a vesical or urethral communication is present In case of doubt, a cystogram may differentiate Urethral communications can invariably be reached from the perineum The dissection is exactly the same as for complete anal atresia or imperforation of the rectum The bowel should be sought close to the sacrum and coccyx The operation of election is to pull the rectum down between the fibres of the external sphincter in the anal dimple and sever the short tract to the urethra If occasion demands it, the surgeon should content himself with opening the bowel and attacking the urethral communication at a subsequent operation when the condition of the patient permits Stettiner reports such an instance in which the prostatic urethra and rectum were separated one month after the initial operation A sound was passed from the urethra into the rectum and the tract was easily identified The opening in the rectum was closed and a small catheter was left in the urethra It is to be remembered that the urethral communication is usually a small orifice Bevan records an instance in which he did a primary colostomy believing that he had to do with a vesical communication, when a perineal dissection was done at five years the communication was found to be with the urethra and it had already closed The writer once failed to note any admixture of feces with the urine, and even at operation, when the rectum was separated from the urethra and prostate, no communication was observed The urine was discharged through the rectum but continence, for both urine and feces, was quite satisfactory In the intervening years the continuity of the urethra has been reestablished Young (1936) reports a similar case

Vesical communications are probably better approached by the abdominal route A cloacal type of termination of rectum and bladder, fortunately rare, presents an extremely difficult surgical problem In such instances, the writer would prefer to deviate the fecal stream completely by preliminary colostomy In the more frequent variety in which a small or narrow tract connects the bladder and rectum, the communication should be severed, the openings in bladder and bowel closed, and the latter adequately mobilized to permit of transference to its normal site of termination A preliminary perineal dissection facilitates the bowel being brought down

In instances, of vaginal termination of the rectum in the female and external fistulous termination in males, that come for the establishment of a functional anus, operation is well deferred until three years of age or later when the transference can be accomplished with greater precision

The mortality incident to operation and pulmonary complications ac counted largely for the large number of deaths in the first week In the group in which proctoplasty was done, late deaths from intestinal obstruc tion due to stricture formation were not uncommon Undoubtedly, considerably better results may be obtained today The writer s experience with instances of imperforation of the anal canal and rectum has been very gratifying Good remote results are also reported by David and Stone

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the new outlet, the glass dilator is worn until the anal canal exhibits no further tendency to stenosis When a satisfactory lumen has been obtained, the wearing of the dilator may be discontinued

The external sphincter of the rectum is normally developed in all cases of atresia of the anal canal or rectum This sphincter develops in connection with the perineum and not with the bowel Hence if the proctodaeum is present, the *surgeon may rely on obtaining an orifice provided* with competent sphincters The difficulty lies in properly anchoring the terminal bowel between the fibres of the sphincter The writer has been much gratified with the continence which these patients have after completion of the operation Chandler (1939) makes no effort to preserve the external sphincter and believes that satisfactory rectal continence may be obtained, nevertheless David (1937) takes pains, in the construction of the rectal outlet to turn in the skin edges to meet the rectal mucosa, in order to insure a dry anal canal

H MORTALITY OF OPERATION

Bodenhammer collected 51 operative cases of imperforate anus from the world literature recorded up to 1879 Of this number he stated that 21 or 41 per cent were successful This figure in part probably does not tell the truth of the matter because of the tendency to report isolated successes rather than failures Ziemendorff collected 114 reported cases of imperforation in the 16 year period between 1893 and 1909 and found that the mortality of colostomy was 79 3 per cent In the 78 cases in which proctoplasty was done, the mortality was 26 9 per cent When the cases of atresia with vaginal communication were omitted, the mortality for proctoplasty was 40 per cent The risk in each group was as follows

TABLE XXX —MORTALITY OF IMPERFORATION

	Mortality
Atresia without fistula	28 6 per cent
Atresia with fistula	26 6 per cent
Atresia with fistula omitting the cases of vaginal communication	58.8 per cent

In the various types of fistulous termination, the mortality was as follows

TABLE XXXI —MORTALITY OF IMPERFORATION ACCOMPANIED BY A FISTULOUS COMMUNICATION

Urethral	37.5 per cent
Vesical	83.3 per cent
Vaginal	9 1 per cent

I REMOTE RESULTS

In a Paris thesis of 1908, Hardouin has summarized the end results in 223 collected cases of imperforation To say the least, they are disappointing as the following will attest

TABLE XXXII —REMOVE RESULTS AFTER OPERATIVE CORRECTION OF IMPERFORATION

55.2 per cent survived one week
44 4 per cent survived one month
22 8 per cent were lost from observation during the first year
13 45 per cent survived for one year
5.82 per cent survived twenty years

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frequently multiple There is an isolated type of tuberculosis known as the hyperplastic variety which occurs with predilection in the cecum and which may occasionally give rise to obstruction of a chronic nature Syphilitic strictures of the small intestine have been reported Following the ulceration of the bowel observed in bacillary dysentery and typhoid fever strictures causing intestinal obstruction have been reported (Braun and Wortman) The ulceration in typhoid is in the axis of the bowel and

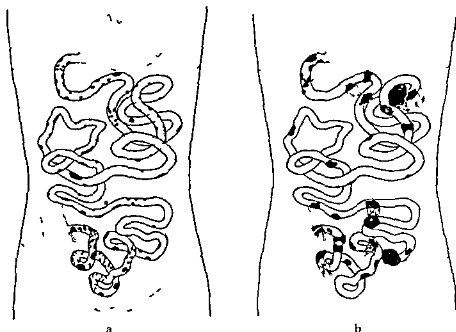


FIG 87—The distribution of benign and malignant tumors in the small intestine (a) Benign tumors (b) Malignant tumors the metastases are shown as radiating lines The larger size of the malignant tumors is apparent (Raiford Arch Surg 25 122 1932)

stricture formation is a rarity Intestinal obstruction, occasioned by narrowing of the greater part of the entire small intestine due to amyloid disease in a patient suffering from multiple myelomas was reported by Randall from this clinic in 1933

In the sigmoid narrowing of the intestinal lumen due to diverticulitis may be observed as an occasional complication in patients past middle life At the sites where the blood vessels penetrate the muscular layers of the colon hernial protrusion of the mucosa may occur Infection in the sacs may give rise to an inflammatory process involving the whole bowel at that level causing obstruction of the lumen The condition simulates malignancy so closely that it is best discussed with carcinoma of the sigmoid flexure

Following blunt trauma to the abdominal wall in which a hematoma forms in the bowel traumatic stricture may ensue It may also be men-

Chapter XIII

INTESTINAL OBSTRUCTION DUE TO TUMORS AND STRICTURES OF THE BOWEL WALL

Prominent among the lesions of the bowel wall itself that narrow the lumen and produce intestinal obstruction are the malignant growths Of less universal interest to the surgeon are a group of conditions less frequent in occurrence but which occasionally bring the patient for relief of bowel obstruction Benign tumors, intestinal strictures as the result of trauma inflammation or previous infarction may be mentioned here *The venereal* diseases—syphilis, gonorrhea, and lymphogranuloma venereum may give rise to rectal stricture As the end result of a phlegmon in the small bowel, *a cicatrizing stenosis may develop Granulomatous inflammatory processes* of uncertain origin also occasionally give rise to stricture formation Ulcerative colitis not uncommonly is followed by the development of strictured areas in the colon

A BENIGN TUMORS

These occur more frequently in the small intestine than in the colon Lipoma, myoma, fibroma, adenoma, and angioma are the more usual offenders Multiple adenomata or polyposis occur especially in the colon, the above mentioned tumors occur with predilection in the small bowel Dewis reported 219 such benign tumors in the intestinal tract in 1906 They not infrequently cause intussusception Of 42 lipomas of the bowel collected by Voeckler, intestinal invagination was observed in 24 Of 986 tumors of the gastrointestinal tract from the Johns Hopkins Collection, Raiford found that 23 8 per cent of all the benign tumors in the group were to be found in the small intestine All the tumors of the small bowel constituted only 8 9 per cent of the entire group and only 4 9 per cent of the *malignant tumors of this series were found in the small intestine* (Fig 87)

Enterocystomas of congenital origin usually found in the lower ileum and not infrequently associated with a persistent *Meckel s diverticulum* occasionally give rise to intestinal obstruction Hannson has collected 48 such cases from the literature Naeslund has collected in a recent inaugural dissertation 96 cases of gaseous cysts of the intestinal wall (pneumatosis cystoides intestinorum) in a few of which instances symptoms of intestinal obstruction compelled operation Nitsch has also described obstruction as a complication of gaseous cysts

B BENIGN STRICTURES

Of the inflammatory ulcers that give rise to strictures, tuberculous ulcer with its axis transverse to that of the bowel is the most frequent It is usually the tuberculous ulcer that exhibits signs of healing that gives rise to stricture formation that eventuates in intestinal obstruction These are

frequently multiple There is an isolated type of tuberculosis known as the hyperplastic variety which occurs with predilection in the cecum and which may occasionally give rise to obstruction of a chronic nature Syphilitic strictures of the small intestine have been reported Following the ulceration of the bowel observed in bacillary dysentery and typhoid fever, strictures causing intestinal obstruction have been reported (Braun and Wortman) The ulceration in typhoid is in the axis of the bowel and

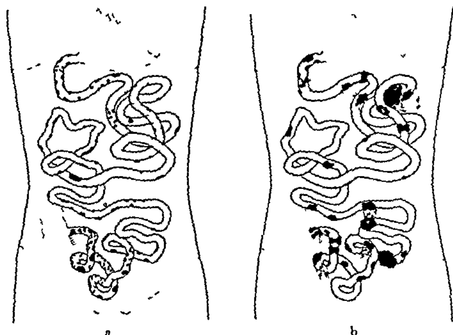


FIG 87—The distribution of benign and malignant tumors in the small intestine (a) Benign tumors (b) Malignant tumors the metastases are shown as radiating lines The larger size of the malignant tumors is apparent (Raiford Arch Surg 25 1?2 193?)

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Following blunt trauma to the abdominal wall in which a hematoma forms in the bowel, traumatic stricture may ensue It may also be men-

tioned that the dissection of a large hematoma in hemophilia has been known to give rise to stenosis Stricture formation consequent upon blunt trauma to the abdomen usually occurs soon after the receipt of the trauma After partial infarction of the bowel as in mesenteric thrombosis, such an event may occur In the extraordinary picture of stricture formation over a considerable portion of the gut depicted by Porter and Welch, of an unusual case of intestinal obstruction of unknown origin, previous infarction would appear to be a likely explanation At any rate, strictures similar to this are not infrequently observed in the dog following de



Fig 88—Stricture formation after devascularization of the small intestine (a) Jejunum of dog excised 77 days after 15 inches had been devascularized by severing and ligating the mesentery near the bowel the omentum being then wrapped around it When excised the length of the segment was 4½ inches and the diameter of the lumen ¼ inch (b) Histological section magnified 10x shows the bowel wall to be receiving its source of blood from new vessels in the omentum All the layers of the bowel wall appear to be somewhat thickened and the mucosa has been considerably altered

vascularization of a segment of the intestine Sometimes, following reduction of a strangulated hernia, a stricture may develop, an occurrence which has become well known since the paper of Garre The inversion of ring-like areas of constriction by employment of interrupted sutures as recommended by Summers (Fig 114 p 351) will help to avoid such subsequent stricture formation Occasionally strictures develop at the neck of an intussusception, some time after reduction After intestinal resection in which the lumen of the bowel has been narrowed a stricture may form which may subsequently give rise to an arrest of the fecal stream especially when objects foreign to the intestine become impacted above it The development of stricture in the bowel following irradiation treatment for malignancy of the female generative organs has been noted (Collins and Jones)

The surgery of these lesions is much as that outlined in carcinoma of the small intestine The true nature of the obstruction usually remains obscure until laparotomy is done In single benign tumors causing intus

susception, enterotomy and excision should be done when circumstances permit Occasionally it will be wiser to reduce the invagination and deal with the tumor later, but, employment of the closed anastomosis makes primary resection the operation of choice in such instances In broad sessile or multiple tumors, intestinal resection is necessary

The role of a generous omentum in protecting and vascularizing short lengths of devitalized gut is to be remembered Bost reported the instances of three patients in which he sutured the omentum successfully over areas of 3 to 4 inches in length, following mesenteric detachment Because of the major surgical problem present in each case, he chose this course of action rather than resection The subsequent development of a stricture in some of these is to be anticipated unless the bowel wall was not wholly devascularized for, as Mall and Eisberg have shown, devascularization of two or three centimeters of the bowel wall usually brings about necrosis In dogs, Scudder Horsley and Coleman, Rothschild, and others have adequately demonstrated that considerable lengths of the bowel may be denuded and revascularized from the omentum The writer observed several years ago in the experimental laboratory that dogs will revascularize regularly from the omentum as much as 6 inches (15 centimeters) of gut after severance of the mesentery In one instance a dog survived after enveloping 15 inches (38 centimeters) of small bowel in the omentum Stricture formation following such procedure however, is to be anticipated (Fig 88)

C MALIGNANT TUMORS

Malignant tumors of the bowel causing intestinal obstruction are found most frequently in the large intestine Nothnagel states that 2 5 per cent of cancers of the intestinal tract are to be found in the small intestine, 26 5 per cent are in the large intestine and 71 per cent in the colon

In 41 838 autopsies performed in Vienna during the period from 1870-1893, Nothnagel found 3585 deaths from cancer of which 343 originated in the intestine Their location is given in the following table

TABLE XXXIII —INCIDENCE OF CARCINOMA OF THE BOWEL

Ileum	10
Jejunum	0
Duodenum	7
Colon	164
Rectum	162

Carcinoma is incomparably more common as the cause of intestinal obstruction than is sarcoma Rademacher collected 140 instances of sarcoma of the bowel in 1908 the greater portion of which distributed themselves in the small intestine Stenosis of the lumen occurred in 14 per cent of these instances but acute intestinal obstruction is relatively infrequent In a recent monograph Staemmler states that 300 cases are to be found reported in the literature Recent studies (Medinger 1939) suggest too that malignancy of the duodenum and ileum is observed more commonly than in the duodenum The writer resected the terminal ileum for a lympho ar

coma causing intestinal obstruction in a woman who now exhibits no residual evidence of the disease after more than 16 years Three additional cases which survived operation have been done recently in this clinic One was a single lesion *in the upper ileum* Perforation occurred while the patient was awaiting operation The risk inherent in this tragic complication was not apparent in the record of convalescence Another patient had multiple lesions through the mid two thirds of the jejuno ileum It was believed to be an ulcerative jejuno-ileitis, but proved, on microscopic study, to be multiple lymphosarcoma (Fig 89) The third patient had an obstructing lesion in the ileocecal valve Preoperative decompression was effected by *an indwelling tube The lesion* involved the mid jejunum by extension, necessitating excision of a segment of jejunum Primary oblique end to end anastomoses were made between the segments of jejunum as well as between ileum and transverse colon Complemental enterostomy was not done

The occurrence of bowel obstruction through the agency of metastatic tumor in the bowel is also to be remembered

Carcinoma of the Small Intestine

Pathogenesis—Carcinoma of the small intestine is relatively infrequent, somewhat more than 400 cases having been reported in the literature to date Many of these had already caused metastases at the time of their recognition The greater number of them gave rise to symptoms of intestinal obstruction of more or less acute nature To be differentiated from them is the carcinoid tumor of the small intestine of which Cooke, in 1931, collected 115 cases It may also produce metastases (20 per cent) This latter tumor is more frequently found in the appendix Intestinal obstruction through the agency of carcinoid tumors has been observed in 16 per cent of the reported instances The lower ileum is most frequently concerned, but the duodenum, jejunum, and even Meckel's diverticulum have been involved Oberndorfer suggested the name of "carcinoid" for this group of tumors in 1907 Carcinoid tumors are to be identified by the silver stain and are commonly called argentaffinomas Carcinoma and carcinoid tumors of the small intestine are usually single, but may be multiple, the largest number occur in the fifth and sixth decades of life There is no predominance in either sex Nothnagel's series is unique in that no cases of carcinoma were observed in the jejunum Raiford reports 88 cases of tumor of the small intestine from the Johns Hopkins material including 11,500 autopsies and 45,000 surgical specimens Sixteen of these were carcinomas Of these, 7 were in the duodenum, 4 in the jejunum, 3 in the ileum, and, in 2, the site had not been stated There were 7 carcinoids of the small intestine in Raiford's group, of which 5 were in the ileum Horsley (1941) states that in the interval of time elapsing since the publication of Raiford's paper in 1932, he was able to find reports of 384 additional cases of carcino[illegible] carcinoid of the small intestine reported in the literature

Pathology—Inte[illegible] on by this mechanism is usually of the [illegible] on does also occur Dilatation of the

intestine with an accumulation of a considerable amount of fluid and gas in the proximal loops is usual At operation, the bowel wall proximal to the obstruction over a distance of two to four feet or more is usually found thickened Microscopic study shows the muscle to be considerably hypertrophied In chronic obstructions the distension is likely to be largely fluid in character In acute occlusions without antecedent obstruction, the content of the distended bowel is principally gaseous By the time that the diagnosis of carcinoma is established metastases have occurred in about

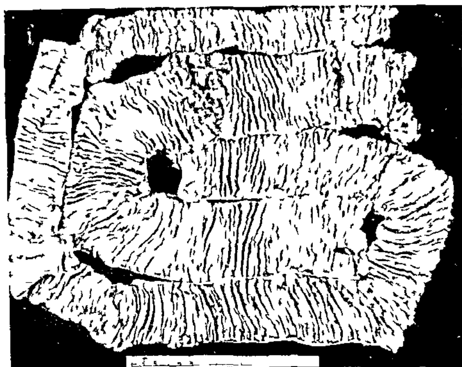


Fig 89—Multiple lymphosarcomas of the small intestine The lesion at X had perforated on to the posterior abdominal wall causing obstruction The multiple lesions in the bowel which proved to be lymphosarcoma on microscopic study necessitated excision of 180 cm or 1/3 of the entire length of the small intestine

25 per cent of instances The mesenteric nodes the peritoneum the liver, and the lungs are the usual sites in the stated order of frequency Stenosing, ulcerating, and polypoid forms may be recognized Adenocarcinoma is the most common histological variety observed Colloid carcinoma of the small intestine is rare

Clinical Features—Of 57 cases of carcinoma of the small intestine collected by Soper in 1909, colicky pain was complained of 28 times a palpable tumor was present in 22 instances Progressive weight loss and vomiting were frequently present Significant in arriving at the diagnosis, Soper (1929) stated in a more recent paper is the finding of occult blood in the stool when the colon and stomach are negative Soper Case and others

have made the pre-operative diagnosis of malignancy in the small intestine causing intestinal obstruction by demonstrating a filling defect with irregular contours in the small intestine as is more often seen in malignant disease in the stomach and in the colon The diagnosis, however, is more readily made from the clinical findings To be certain, a benign stricture of the gut cannot always be differentiated Periodic attacks of acute obstruction with long free intervals between favors a benign stricture Progressive weight loss and a shorter history speak for carcinoma of the small bowel Enlargement of the abdomen may attend stricture formation in the small bowel as occurs commonly in the megacolon of Hirschsprung's disease (Fig 90)

In the experience of the writer, the correct diagnosis can usually be made on the basis of the presence of symptoms of intestinal stenosis due to narrowing of the lumen or stricture formation The roentgenologist rarely identifies the presence of carcinoma of the small intestine by barium studies, for as can be understood the barium does not often accumulate proximal to the tumor in sufficient amount to cause a filling defect In most instances that have come under the writer's attention the stasis ray will not detect delay of transit of barium through the small intestine However, the balloon tipped Miller Abbott tube has been an agent of real value in identifying the presence of a lesion in the small intestine, if its presence is suspicioned The usual history is that of periodic intestinal colic and occasional vomiting If the patient comes for examination during such an attack, the intestine can usually be seen and felt with the palpating hand through the abdominal wall as a series of elevations and depressions (Fig 21, p 101) "wash board abdomen" A duodenal tube will ordinarily recover a feculent material from the stomach and the scout film of the abdomen will show dilatation of coils of the small intestine Carcinoma of the ileocecal valve gives the picture of obstruction of the small intestine If such an acute attack of obstruction subsides a stasis ray with barium may still fail to reveal the obstruction which was so obvious during the acute seizure and the scout film will show no gaseous distension of coils of small intestine Similarly, the intestinal coils may now no longer be seen or felt This unusual occurrence is to be accounted for in that the fluid content of the terminal ileum may go through a stenotic orifice without great difficulty If however the stenosis is almost complete, spontaneous reestablishment of intestinal motility and transport is not to be expected



Fig 90—Enlargement of the abdomen in stricture of the small intestine In an acute attack the hypertrophied coils of bowel could be seen and palpated A Meckel's diverticulum causing intussusception had been amputated 6 months previously

Treatment—In 1912, Hintz summarized the operative treatment of 44 cases of carcinoma of the small intestine, 16 of these showed definite evidence of stenosis The prognosis in the group as a whole is poor Hellstrom says that of 62 radically treated cases that have come to his attention, 16 per cent have been cured Cases exhibiting evidence of obstruction come to operation at an earlier date

It is an interesting and significant fact that in the four cases not exhibiting intestinal obstruction radically operated upon (Hintz), there was only one operative death In the twelve instances in which resection

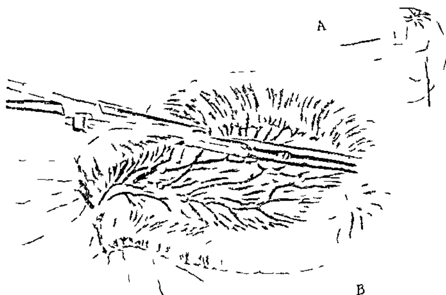


FIG 91—Primary resection of the small intestine for a malignant stricture causing obstruction A The angle of resection B Placement of the resection clamp upon the bowel A heavy Ochsner clamp is applied just beyond the aseptic anastomosis clamp

was done in the presence of intestinal obstruction, there were six operative deaths

Preliminary successful decompression of such obstructions by an indwelling duodenal tube however puts a new complexion on the picture makes the task of the surgeon considerably easier and lowers the risk When preliminary deflation can be accomplished by an indwelling duodenal or a Miller Abbott tube, a primary resection can be done In event, the character of the distension is such that the duodenum can not be intubated the surgeon has a real problem to face, in relieving the distension by operation He may choose one of the following (1) enterostomy

(2) exteriorization, with the establishment of an external fistula (3) entero anastomosis or (4) resection with primary anastomosis More and more, the writer is inclined to extend the indications for employment of primary resection in such cases, employing, of course, the closed anastomosis As has previously been pointed out (page 206) the surgeon who essays to do a primary resection in the presence of considerable distension must deal with the distention satisfactorily, before he can consider undertaking primary excision of the tumor Possible maneuvers (aseptic decompressive enterotomy) by which the distension may be dealt with have been discussed already (page 209) The general criteria which determine the choice of operative procedure in such instances was discussed at length under the section of Operation in bowel obstruction (Chap VII)

Carcinoma of the Large Intestine

Pathogenesis —It is in the sigmoid flexure that carcinoma is especially apt to eventuate in acute intestinal obstruction This occurrence owes its



Fig 92—*Carcinoma of the transverse colon (a) Roentgenfilm showing perforation into the descending colon* (b) The excised specimen—the stomach was involved by extension demanding sacrifice of a good portion of the greater curvature Primary resection with anastomosis between the transverse and pelvic colon was done The lesion was excised en bloc including the abscess channel of communication between transverse and descending colon The patient has remained well

explanation no doubt in large measure to the fact that this part of the colon has the smallest diameter as well as to the fact that circumscribed annular growths frequently occur there Obstruction in the left half of the colon is 8 times as frequent as obstruction in the right In every 10 cases of colonic obstruction, 9 are due to carcinoma About one third of the cases of carcinoma of the colon give rise to intestinal obstruction of an acute or chronic nature

Korte stated that 39 per cent of the cases of carcinoma of the bowel which he collected presented themselves for treatment with clinical features of intestinal obstruction Anschutz reports that 63 per cent of cases

of carcinoma of the pelvic colon give rise to intestinal obstruction, 52 per cent of the lesions at the splenic flexure 44 per cent at the hepatic flexure, and 25 per cent of those at the cecum obstruct Included in this number are many cases with low grade obstruction

Carcinoma is the most common tumor of the colon Rankin, Bargen and Buie state that up to 1929, 55 cases of carcinoma had been observed



Fig 93—Large primary carcinoma of the stomach involving transverse colon A The crater of the gastric carcinoma B Perforation on to the transverse colon causing partial colonic obstruction Resection of the stomach with excision of the transverse colon and establishment of a colostomy Subsequent closure of colostomy As an alternative procedure primary resection of colon with oblique end to-end anastomosis could have been made also The patient has been well since operation 2 years ago Carcinoma of the stomach invades the transverse colon and its mesentery necessitating partial colectomy not infrequently Partial resection of the stomach because of extensions from a primary carcinoma of the colon is by no means frequent (see Fig 92)

in the small intestine, 4597 in the colon and rectum and 4335 in the stomach In this Mayo Clinic series carcinoma occurred most frequently in the pelvic colon and cecum and more commonly at the flexures They call attention to the high incidence of obstruction in splenic growths owing to the acute angulation at the splenic flexure

Of 458 cases of carcinoma of the colon observed at the Royal Infirmary at Manchester over a 10 year period 173 or 35 6 per cent, Burgess found exhibited evidence of acute intestinal obstruction In 86 7 per cent of these cases the obstruction occurred in the left half of the colon

The anatomical arrangement of the flexures is perhaps in part an explanation for the more frequent occurrence of obstruction at these sites than in other portions of the colon The greater frequency of obstruction on the left side is due in no small part undoubtedly to the solid form assumed by the feces after the mid portion of the transverse colon has been passed whereas on the right side the feces are distinctly liquid In the following table from Miller the incidence of carcinoma and obstruc-

tion in the various segments of the colon is apparent. Twenty per cent were admitted with acute obstruction and 40 per cent gave a history of chronic obstruction.

Pathology.—Colonic obstructions are essentially simple in nature. The role of the ileocecal valve and sphincter in converting an occlusion of the colon into a strangulating obstruction with necrosis, gangrene and perforation, and usually of the cecum has been pointed out (p. 30). Hechl called attention to the importance of the ileocecal valve in bringing about perforation in the presence of colonic obstruction as long ago as 1880, but

TABLE XXXIV.—INCIDENCE OF OBSTRUCTION IN CARCINOMA OF THE COLON (Miller)

Location of Obstruction	Cases	Incidence of obstruction per cent	Acute obstruction	Chronic obstruction	Non obstruction
Cecum	50	38	2	24	24
Ascending colon	5	4	1	1	3
Hepatic flexure	12	9	2	6	4
Transverse colon	7	5	4	2	1
Splenic flexure	8	6	2	3	3
Descending colon	6	5	2	1	3
Sigmoid	40	31	12	16	12
Hepatic flexure combined with second growth in ascending colon	1				

the significance of its occurrence is not yet fully appreciated. Perforation is more likely to occur in acute obstruction than when the occlusion has developed slowly, permitting of thickening and hypertrophy of the bowel wall. The papers of Shimodaira and Sperling are of particular interest in this connection. In 1931 the hazard of the closed loop in colonic obstructions was first noted in this clinic. By 1934, the writer felt warranted in distinguishing, rather sharply, the findings of large and small bowel obstructions.

Volvulus may occur, especially when the obstruction is in the sigmoid flexure. Intussusception also occurs, but is unusual. It obtains with predi lection in the presence of polypoid tumors and is most prone to occur in the sigmoid flexure and in the cecum. A chronic type of intussusception usually ensues. Carcinoma of the cecum, that causes acute intestinal obstruction has often attained unusual proportions and metastases to the peritoneum or adherence to adjacent structures are not infrequent. Small constricting annular growths are frequent in the pelvic colon and may give rise to acute obstruction in the absence of antecedent symptoms. In the cecum, larger bulky growths are more frequent. Adenocarcinoma is most frequent, colloid carcinoma constitutes about 5 per cent of tumors of the large bowel. The cecum and rectum are the most frequent sites for its development.

Clinical Features.—Acute intestinal obstruction occurring in patients of

middle and advanced years who have long complained of abdominal discomfort is often due to carcinoma of the colon Almost invariably a history of constipation extending over some period of time is obtained, there frequently have been attacks of abdominal pain associated with temporary meteorism, during which time the expulsion of gas and feces, has been accomplished with extreme difficulty or not at all The observation of blood or mucus in small quantities in the stool has, at times, been previously noticed, alternating periods of constipation and diarrhea may be complained of Anschütz states that in his series, fourteen came with acute intestinal obstruction, as the first evidence of the disease When such a patient presents himself for examination, the abdomen is frequently distended and occasionally the patterns of the colon may be seen in the form of a horseshoe shaped swelling around the periphery of the abdomen

Vomiting is not infrequently absent altogether despite enormous distension Occasionally vomiting may be present initially The duodenal tube may reveal that gastric retention is absent These significant findings owe their occurrence to the action of the ileocecal valve and sphincter and are of great value in helping to determine the exact nature of the obstruction present A patient with occlusion of the colon may not appear particularly ill yet it is one of the most vicious obstructions observed clinically

Digital examination of the rectum frequently shows this cavity to be empty Bimanual palpation aided with one hand over the abdomen occasionally renders a mass palpable which could not be felt by abdominal palpation or rectal examination alone The abdomen though tympanitic, is moderately soft and not tender, when tenderness is present it is usually found over the cecum—a warning that the viability of the bowel is threatened by the enormous distension The presence of weight loss secondary anemia and a tumor mass in a patient of the cancer age lend confirmation to the probable presence of a neoplasm in the colon A tumor is rarely palpable in the acute obstructions of the pelvic colon Visible or palpable peristalsis can be made out occasionally when previous obstructive attacks have preceded *Intestinal colic* is invariably present, the gas pains usually do not recur however at such short intervals as in obstruction of the small intestine In consequence the examiner frequently finds it necessary to auscultate longer at the bed side to establish the presence of *intestinal colic.*

In the experience of the writer distension in obstruction due to carcinoma of the colon has been limited usually to the colon (Figs 12 and 23) When the film is made with the patient lying prone gas may occasionally be observed in the terminal loops of the ileum—probably regurgitated from the colon because of the compression brought about by having the patient lie on his abdomen Gas may of course, be demonstrated in the ileum in patients with colonic obstruction—the usual cause being that one of the lips of the ileocecal valve is deficient (usually the lower lip), permitting ready regurgitation back into the ileum

Intestinal colic accompanied by great distension limited to the colon and little or no vomiting serve to identify this type of obstruction one would naturally conclude that the barium enema would be of great help

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Vomiting is not infrequently absent altogether, despite enormous distension Occasionally, vomiting may be present initially The duodenal tube may reveal that gastric retention is absent These significant findings owe their occurrence to the action of the ileocecal valve and sphincter and are of great value in helping to determine the exact nature of the obstruction present A patient with occlusion of the colon may not appear particularly ill, yet it is one of the most vicious obstructions observed clinically

Digital examination of the rectum frequently shows this cavity to be empty Bimanual palpation aided with one hand over the abdomen occasionally renders a mass palpable which could not be felt by abdominal palpation or rectal examination alone The abdomen though tympanitic, is moderately soft and not tender, when tenderness is present, it is usually found over the cecum—a warning that the viability of the bowel is threatened by the enormous distension The presence of weight loss secondary anemia, and a tumor mass in a patient of the cancer age lend confirmation to the probable presence of a neoplasm in the colon A tumor is rarely palpable in the acute obstructions of the pelvic colon Visible or palpable peristalsis can be made out occasionally when previous obstructive attacks have preceded *Intestinal colic* is invariably present, the gas pains usually do not recur however at such short intervals as in obstruction of the small intestine In consequence, the examiner frequently finds it necessary to auscultate longer at the bed side to establish the presence of *intestinal colic*

In the experience of the writer, distension in obstruction due to carcinoma of the colon has been limited usually to the colon (Figs 12 and 23) When the film is made with the patient lying prone gas may occasionally be observed in the terminal loops of the ileum—probably regurgitated from the colon because of the compression brought about by having the patient lie on his abdomen Gas may, of course be demonstrated in the ileum in patients with colonic obstruction—the usual cause being that one of the lips of the ileocecal valve is deficient (usually the lower lip), permitting ready regurgitation back into the ileum

Intestinal colic accompanied by great distension limited to the colon and little or no vomiting serve to identify this type of obstruction one would naturally conclude that the barium enema would be of great help

in establishing the presence of the obstruction When the roentgenologist finds a mechanical impediment to complete filling of the colon, on the administration of a barium enema, this examination contributes worth while information Instances have come to the attention of the writer, however, in which barium went through the *stenosis without great difficulty*, and yet an obstruction so complete in nature was present that perforation of



Fig 94—Partial colectomy for malignancy of right colon A Division of avascular *ligament mobilizing colon On completion of the operation this defect must be closed* carefully taking care not to angulate the duodenum B Completed oblique anastomosis between the end of the ileum and the transverse colon The terminal 2.5 to 3 *feet (50 to 75 cms) of the ileum is removed regularly with the cecum ascending* and right half of the transverse colon Excision of a segment of the ileum is necessary with sacrifice of the mesentery to effect satisfactory lymph node removal and also because *of sacrifice of the terminal ramifications of the ileocolic artery Reversal of mesentery* (Dennis) is shown here (see Fig 64)

the cecum was later found One can only conclude therefore that in the presence of great distension the barium enema, even in practiced hands, *is not to be depended upon for the identification of a tumor in* the same measure, as when the lesion does not obstruct The scout film of the abdomen correlated with the clinical findings is more reliable

Differential Diagnosis—That intestinal obstruction exists in such patients is rarely demanding of proof The determination of the exact type of obstruction can not always be made *with certainty Compression of* the bowel by pelvic masses frequently cannot be differentiated except by the operative findings Even operation may fail to differentiate a carcinoma

of the colon from diverticulitis Their simultaneous occurrence, especially in the sigmoid flexure has been pointed out by W J Mayo and others The presence of a palpable tumor, Judd and Pollock found to be more in favor of the presence of diverticulitis than of carcinoma A barium enema will frequently detect diverticulas, but the aid of the microscope must occasionally be enlisted to determine whether malignancy may not be present concomitantly

Obstruction of the small bowel can usually be readily distinguished by the occurrence of frequent and copious vomiting and by the distended loops of small intestine seen in the skiagram One of the most difficult differentiations to make, and one which occasionally cannot be made without recourse to operation, is that of distinguishing a spastic obstruction of the colon from a mechanical block The writer has previously described some of these difficulties (1931) The intervening years have not lessened the perplexity of this difficulty If the barium enema were as reliable in detecting the presence of a block in the bowel when clinical obstruction is present as when it is not, this confusion would not obtain The writer's practice has been to operate if an adequate differentiation cannot be made Even at operation granted that the distension is not too great to preclude careful palpation of the pelvic colon a satisfactory distinction cannot always be made If following the establishment of colostomy, a barium enema fails to disclose a block, it may be reasoned that the obstruction was spastic in character

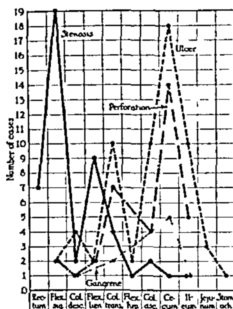


Fig 95—The most frequent location of obstructions which give rise to intestinal perforations in simple bowel occlusion (Shimodaira Mitt a d Grenzgeb d Med u Chir 22:229 1911)

Treatment—Nowhere is better illustrated the importance of merely relieving the distension at the first operation, than in surgery of malignancy of the large bowel The mortality of operations for cancer of the large bowel in the presence of intestinal obstruction is more than doubled for the same type of operation done in the absence of obstruction Körte has collected 58 cases of intestinal obstruction caused by malignancy of the colon that were radically operated upon—(cases operated upon by five surgeons—Mikulicz Rotter Eiselsberg Korte and Berg) The mortality was 60 per cent Exteriorization by the Bloch Mikulicz method was made in 11 cases with a 63 per cent mortality It is also too major an undertaking for patients ill with a neoplastic process and further handicapped by the presence of an acute intestinal obstruction In 34 instances

in which the same 5 surgeons made a primary entero anastomosis, the mortality was 64 per cent, whereas the mortality of entero anastomosis in another 114 cases of tumor of the large intestine, in which no obstruction was present, was only 16 2 per cent (Körte)

The operation that enjoys widest usage in the relief of obstruction of the colon is cecostomy The difficulty, however, is that it is almost impossible *to do an aseptic* operation on the distended cecum unless it is well exteriorized, unacceptable as such exteriorization may be, it also obviously would be exceedingly difficult to accomplish in the presence of great dis



FIG 96—Perforations of the descending colon due to a carcinomatous stricture of the pelvic colon Perforation occurred twelve days after cecostomy The impaction of feces in the bowel and the acute angulation of the splenic flexure were probably responsible (Sperling Arch Surg 32 22 1936)

tension of the cecum The writer has observed perforation of the descending colon after relief of colonic obstruction by cecostomy (Fig 96) In decompressing the distension of an obstructed colon, the writer has come to permit himself to be guided wholly by the x-ray film In the majority of instances, the distension will be found to extend into the pelvic colon The place of election for the establishment of decompression in such an instance will be the transverse colon With an opaque object fastened to the umbilicus when the x ray exposure is made (Fig 23) the incision can be placed directly over the distended colon If it is presumed that the lesion is a carcinoma which will necessitate a subsequent operative attack, it is best to make a right transverse incision (Fig 50), if on the contrary, the operation is to be somewhat in the nature of an exploratory operation as well, a more direct approach to the pelvic colon will be had through a left transverse incision A transverse incision is to be preferred in that the colon will present itself directly into the wound, at the same time, evisceration is much less likely to occur after this incision Whereas the mortality of acute obstruction of the colon from malignancy was in the vicinity of 50 per cent at the University Hospital, when cecostomy was employed to decompress the distended colon the mortality, with employment of an aseptic method of decompression the colon, should ap-

proach zero It is astounding how simple and effectual transverse colostomy performed after the method outlined on page 199 is Cecostomy can never compete with it in ease of performance or in mortality A second year surgical house officer can relieve an obstructed colon by an aseptic transverse colostomy with less risk to the patient than can an experienced surgeon who favors performance of cecostomy As a complemental procedure to primary resections in the left colon appendicostomy or cecostomy is a simple and, occasionally, a desirable procedure



Fig 98—Subtotal colectomy for polyposis There were 3 frank carcinomas in the bowel one in the pelvic colon causing obstruction one in the transverse colon and another at the hepatic flexure There were scattered polyps between The rectum and cecum were free The type of operation shown in Fig 99 was done

If the obstructive lesion is found in the hepatic flexure or nearer the site of termination of the ileum in the cecum it is obvious that this obstructed segment must be tapped If the vermiform appendix be present and patent the operation performed most readily will be found to be appendicostomy usually Another manner of effecting the decompression with relative ease and safety is to perform enterostomy on the very terminal ileum pushing the catheter through the ileocecal valve into the distended cecum Cecostomy is to be reserved for the occasional case

Carcinoma of the ampulla of the rectum gives rise to intestinal obstruction rarely At the level of the peritoneal reflection, stenosis may occur though usually of the chronic variety A left inguinal incision with the establishment of a complete diversion of the fecal current in such cases,



Fig 98—Primary subtotal colectomy for chronic ulcerative colitis Operation completed in one stage as indicated in Fig 99 The rectum and cecum were uninvolved The patient gained 85 pounds in a few months and has remained well

is indicated The surgical treatment of diverticulitis causing intestinal obstruction is that of carcinoma of the same segment of the colon Haberer's suggestion that a one stage resection be done in instances of acute obstruction of the colon appears out of keeping with what experience has shown to be best in obstruction

Technique of Dealing with the Neoplasm in the Bowel After Obstruction Has Been Relieved

As has been stated above, obstruction in the left colon is considerably more frequent than in the right In consequence a number of patients with lesions in the pelvic colon and splenic flexure, particularly have had to have a preliminary colostomy *for the relief of obstruction A number of* patients with mild obstructive symptoms and with modest distention can be decompressed satisfactorily by an indwelling duodenal tube At an early subsequent date, the operation of election may then be done without an antecedent decompressive operation (For technical details see Chapter VIII)

For a period of about four years it has been the practice in this clinic to perform resection with primary anastomosis for unobstructed lesions in both the right and the left colon Within the past year, the standard practice has become to make an oblique end to end anastomosis, usually with omission of complemental enterostomy or colostomy If an antecedent colostomy has been made for obstruction of a left sided lesion, the colostomy is closed subsequently When the colostomy is near the site of the tumor, however, the bowel employed in the colostomy has, on occasions,

been excised with the tumor—the operation being completed by the performance of a primary anastomosis

For malignancies of the right half of the colon an oblique end to end anastomosis between the ileum and the transverse colon is made following

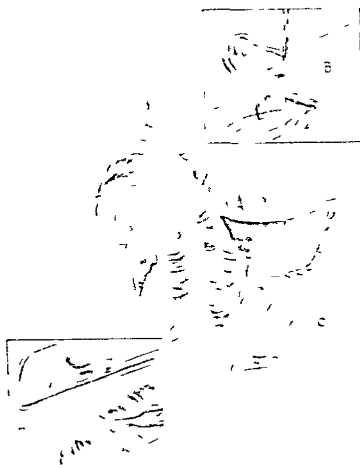


Fig 99—Subtotal colectomy for multiple lesions in the colon with end-to-side anastomosis between pelvic colon and side of cecum. This type of operation as a single stage procedure has been done for multiple carcinoma (pelvic colon and hepatic flexure) and for polyposis and chronic ulcerative colitis without involvement of the rectum or cecum A Use of v Petz suturing apparatus in the division of the ascending colon B Inversion of the divided colon with interrupted Halsted mattress suture C The completed oblique end to-side anastomosis between side of cecum and end of pelvic colon. Closure of the mesenteric defect is accomplished with surprising ease usually after subtotal colectomy

excision of the cecum ascending and the first part of the transverse colon (Fig 94) In the sigmoid flexure mobilization with end to-end anastomosis suffices usually (Fig 61) For lesions in the descending colon it has been necessary to mobilize both sigmoid and splenic flexures In



stration in colon surgery In small bowel resections, the mortality differences may not be so apparent Yet, he who has schooled himself in the niceties of the closed anastomosis will come to prefer it to all others In this clinic all anastomoses in the alimentary canal for more than a three year period, have been made by the closed method The only occasion for dealing with an open bowel has been in the closure of colostomies When surgeons come to appreciate generally the safety and the ease with which closed anastomoses may be made in the gastro intestinal canal the procedure will come to enjoy more common usage

For obstruction of the small intestine occasioned by neoplasms enterostomy, exteriorization and entero anastomosis are alternative operative procedures If the factor of distension has been dealt with satisfactorily by suction applied to an indwelling duodenal tube primary resection is probably the procedure of choice The chief problem presented by such cases is how to deal with the distension And, of course, were it not for this problem of distension, the surgery of intestinal obstruction would not be so difficult

In the past decade the therapy of bowel obstruction has been advanced principally by employment, and extension of the use of suction applied to indwelling intestinal tubes That method too has its shortcomings and for the years that lie immediately ahead, this writer believes that greater progress will come through improvements by the surgeon, directed at dealing with the problem of distension as presented at operation Distension was the bugbear of surgeons before conservative decompression had its vogue, and it still is the stumbling block in the management of those cases in which suction has failed McKittrick and Sarris (1940) have alluded to this circumstance recently also Aseptic decompressive enterotomy described under Caption Q in Chapter VII will lessen the hazards when operations must be undertaken in the presence of great distension of the small intestine

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order to avoid tension at the anastomosis, the writer excises the splenic flexure and the descending colon, establishing intestinal continuity by primary oblique end to end anastomosis between the distal portion of the transverse colon and the pelvic colon (Fig 99)

For a low-lying lesion in the pelvic colon, near or below the peritoneal reflexion, primary anastomosis may be difficult In such a situation, it may be necessary to place the inner posterior sutures, before tying the outer interrupted row of Halsted mattress sutures The anterior suture is not difficult to make ordinarily The writer has transplanted successfully a loop of ileum with its blood supply intact anastomosing it to the infraperitoneal portion of the rectum, by oblique end to end union, in order to reestablish intestinal continuity after sacrifice of the pelvic colon Such an anastomosis can be made only as stated above, by placing all the posterior sutures before any are tied

A deterrent to reestablishment of intestinal continuity, apart from the technical difficulty involved in the procedure, is that excision of the entire pelvic colon necessitates sacrifice of the superior hemorrhoidal artery, the end vessel of the inferior mesenteric artery In such instances, therefore, the residual rectum is dependent upon the middle and inferior hemorrhoidal arteries for its blood supply When primary anastomosis is undertaken in such instances care must be observed not to mobilize the infraperitoneal portion of the rectum too much Further, the color of the distal segment must be good before the anastomosis is undertaken If the surgeon has any misgivings over the character of the blood supply to the lower segment, it is best to complete the operation as an anterior resection, by establishing colostomy and inverting the distal end or as a one stage abdomino perineal operation excising the rectum completely

In the experience of the writer, the end results of excision of carcinoma of the colon are very good—probably superior to any other malignancy in the alimentary canal There is far more justification for attempting aggressive, even palliative surgery for carcinoma of the colon than for gastric malignancies The probabilities are that carcinoma of the colon is a less malignant neoplasm than carcinoma of the stomach Primary resection presents a distinct advantage over the exteriorization operation in that it offers a better opportunity to excise completely the lymph node area involved The writer does not hesitate to perform primary resection in the presence of hepatic metastases

The experience of this clinic is that in the absence of a perforated lesion, primary closed anastomoses for colonic malignancy, can be done at a risk of about five per cent It is the impression of the writer that in practiced hands, the risk of the primary closed anastomosis is definitely less than for the multiple stage Bloch Paul Mickulicz exteriorization Mayo and Lovelace, in reviewing recently the experience of the Mayo Clinic in the surgical management of carcinoma of the colon came to the same conclusion

In the opinion of the writer, the closed anastomosis presents such definite advantage over the open, from the standpoint of mortality that the open operation should be discarded This thesis is particularly easy of demon

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Chapter XIV

OBTURATION OBSTRUCTION

A INTESTINAL OBSTRUCTION DUE TO GALLSTONES

Pathogenesis

Intestinal obstruction, due to gallstones, owes its origin almost invariably to an abnormal communication between the biliary passages and intestine Most frequently this internal biliary fistula is established between gall-bladder and duodenum, though such a communication between common bile duct and *stomach or jejunum, ileum, or colon may occasionally* obtain There are on record reported instances in which an intestinal obstruction is said to have occurred in the absence of an abnormal com munication Moynihan refers to 2 instances of this sort, but it would appear very unlikely that gallstones large enough to cause a mechanical block could pass through the biliary tract into the intestine in the absence of such an irregular opening However, it is to be admitted that gallstones have been known to cause intestinal obstruction when too small to block the lumen of the bowel In such instances, a dynamic or spastic obstruc tion is brought about through the agency of the gallstone The late Sir *Frederick Treves found in the museum of Guy's Hospital a gallstone that* weighed less than 4 grams (55 grains) that caused fatal intestinal obstruc tion Such obstructions are undoubtedly spastic in nature and can be adequately dealt with by suction applied to an inlying duodenal tube Two such cases have been treated conservatively, successfully by the writer in which the gallstone later appeared in the stool

Gallstone obstruction, though infrequent, is decidedly not a rare occur rence Wagner found a total of 334 cases on record in 1914 Gibson col- lected among 646 cases of intestinal obstruction, 40 of this variety Barnard at the London Hospital over an 8 year period, during which *time 360 cases were admitted to the wards, observed 8 cases of gallstone* obstruction In the papers of Fitz and Leichtenstern representing, like the series of Gibson, collected material, gallstone obstruction occurred in the ratio of 1 to 13 in the series of Fitz, and in Leichtenstern's series, 1 in every 28 cases was one of gallstone obstruction

The usual site for the lodgement of the stone that causes obstruction is the lower ileum Out of 239 cases of gallstone obstruction collected by Wolfler and Lieblein, 90 were present *in the lower third of the ileum*

In the cases collected by Courvoisier, lodgement of the obstructing calculus was in the duodenum or jejunum in 21 4 per cent of the cases *in the ileum*, in 65 4 per cent, in the ileocecal valve, in 10 per cent, and in the sigmoid flexure, in 2 4 per cent

Stones large enough to occlude the lumen of the intestine are ordinarily about the size of a walnut Round stones are much more likely to cause

obstruction than ones of equal weight with a greater length Rough or facetted stones are apparently more likely to cause obstruction than those that are perfectly smooth Enlargement of gall tones during their passage through the intestine may also occur This is especially likely to happen if the stone remains in any portion of the intestine for any length of time, and particularly if medicaments, such as bismuth subnitrate, calcium or magnesium carbonate, are being taken orally Grey-Turner has recently reported successful extraction of 2 gallstones from the transverse colon of an 81 year old man who had been obstructed from time to time over a period of many months The larger stone was 7 inches (17.8 centimeters) in circumference and weighed 5 ounces (150 grams)

Holz tabulated 5 instances in which gall tone obstruction occurred in the same individual more than once In 3 of these cases, the second gallstone was removed during the immediate convalescence such that it was likely that there were 2 stones in the intestine at the time of the operation, the existence of the second stone not being noted at the initial operation

In consonance with the more frequent occurrence of gallstones in women, gallstone obstruction of the bowel occurs 3 times more frequently in women than in men people of middle life and advanced years are most often attacked Wortmann reports the instance of gall tone obstruction in a woman of 25 and states that this is the youngest age at which this type of bowel obstruction has been observed

Pathology

Gallstone obstruction is usually of the simple variety in which a mechanical block alone is present Occasionally such an obstruction partakes of the nature of volvulus, due to the fact that when fluid and gas accumulate above the point of obstruction owing to the increased weight of the segment such a loop may undergo torsion Henning was able to bring about volvulus or torsion in ligated loops of cadavers by the introduction of water proximal to the obstruction Mayo Robson and Smith have noted this type of intestinal obstruction by a gallstone The presence of perforating ulcers in the intestine above the point of obstruction incident to the extreme dilatation of the intestine has been noted also Occasionally necrosis of the bowel wall at the site of the incarceration occurs Gallstones have become lodged in Meckel's diverticulum (Hanke)

Clinical Features

The history of previous gallbladder disease may occasionally be obtained, cholangitis may or may not have previously been present Schuller noted the occurrence of fecal vomiting in 77 of 120 reported cases and a palpable tumor in 20 instances the latter observation is significant of the fact that cases of this sort are very likely to go unrecognized for an unduly long time By virtue of the nature of the obstruction, it is easily seen how this may obtain The diameter of the upper intestine being larger than of the lower, the presence of such a body foreign to the intestine may initiate cramps during its transit through the upper intestine, it may

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become temporarily lodged at a given point, giving rise to mild obstructive symptoms, only to be swept on later by vigorous peristalsis and then, finally to the lower ileum, where the lumen of the intestine is smallest This occurrence is an item of importance in the dignosis A stone may be present in the intestinal canal for some time before becoming firmly wedged and impinged in position The persistence of Murphy buttons in the intestine for a long time with the late development of intestinal obstruction is well known

Diagnosis

Though a correct preoperative diagnosis is rarely made if the condition is borne in mind it should be recognized in the majority of instances As was pointed out above an obstruction which relents and recurs should suggest an obturative type of obstruction An antecedent story of biliary colic with cholangitis should suggest the possibility of gallstone obstruction Occasionally, the diagnosis is made first, on inspection of an x ray film When gallstone obstruction is suspected to be present, films should be taken in several directions Occasionally, a large biliary calculus in the intestine may be missed on a posteroanterior film, but may be recognized in an oblique film The presence of air in the biliary passages suggests that the presence of an internal biliary fistula, through which the gallstone may have found its way into the intestine (Rigler and Borman 1937) When roentgen films have been made of the gall bladder previously, demonstrating the presence of a large calculus, the area should be re examined, in the presence of *intestinal colic* to determine whether the shadow is still there This occurrence has proved helpful in a patient in this clinic, an occurrence which McWhorter reported as long ago as 1929



FIG 100—Gallstone obstruction The patient Mrs A T., aged 70 Univ Hosp No 618442 had a story of abdominal pain of short duration with abdominal tenderness The pain relented and recurred A barium study of the intestinal canal caught the stone nicely (6) A communication with the biliary tract is shown at 5 Enterotomy as shown in Fig 102 was done

In the experience of the writer obstruction occasioned by a gallstone, is attended usually by abdominal tenderness owing probably to progressive pressure necrosis at the site of incarceration of the stone Whereas, obturation of the bowel is essentially a simple type of obstruction it exhibits early the effects of a strangulating obstruction, at the site of arrest of the biliary calculus in the intestine

In the cases that have been observed in this clinic, during the last few

years, the diagnosis has either been made, or the presence of a gallstone suspicioned by one of the observers In earlier years, the condition was diagnosed rarely There is a definite story of *intestinal colic*, accompanied by vomiting The pain relents for several hours, then recurs again with vomiting This occurrence may be repeated several times, suggesting lodgement and forward progression of the obturative mechanism, corresponding in time to presence or absence of obstructive symptoms The disorder is notably difficult to identify However, consideration of its occurrence as a possibility helps immeasurably

Neligan (1915) reported an instance of bowel obstruction in which gall stones were vomited into a pan with such force that the sound suggested that a volley of buck shot had been fired into a metal utensil On counting them Neligan found there were about 30 Later Neligan says the patient passed a large stone while on the bed pan which produced so much noise that "he and everyone else were frightened The family summoned Neligan but they could not repress their curiosity and before he got there the stone had been broken with a hammer Neligan naively remarks 'Surely Nature has never made a more determined or successful effort to get rid of gall stones'

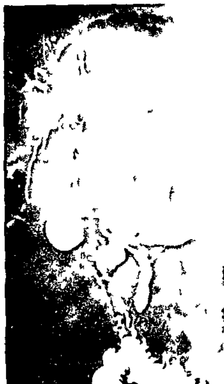


FIG 101—*Air and barium in the bile ducts* Evidence is good that there is an abnormal fistulous communication between the biliary tract and the intestine—the usual antecedent of gall stone obstruction

Differential Diagnosis

Adhesive obstructions of the small intestine and an enteric intussusception have to be differentiated Often this distinction can only be made at operation The vomiting the pain and the distension as revealed in the x ray film help to distinguish gall stone obturation from enterocolitis The temporary periods of remission in the symptoms which may occur during the progression of the stone until it becomes arrested finally, may confuse the observer It is to be remembered that this occurrence is not infrequent in gallstone obstruction

Treatment

Suction applied to an inlying duodenal tube will accomplish decompression in some instances and permit extrusion of the stone Per

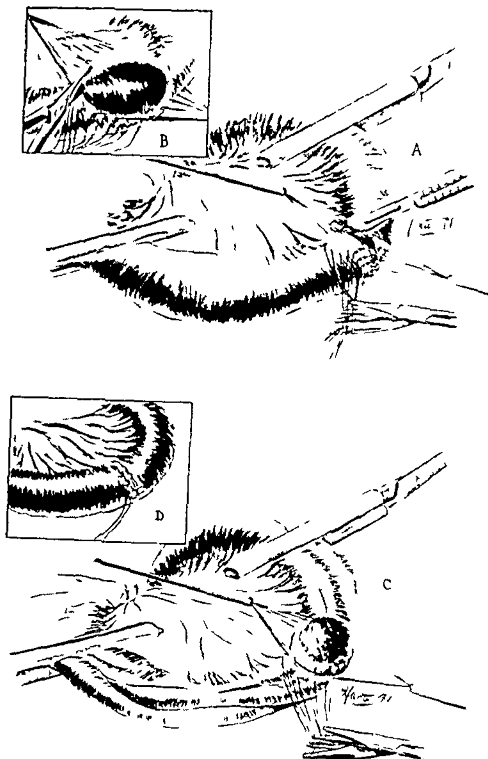


FIG 102—*Technique of aseptic operation for removal of gall tone from inte tine* (A) Placement of Halsted mattress sutures The stone has been dislodged proximally

sistence of intestinal distension, as revealed by x ray examination after a trial with suction, indicates the necessity for operation Operation at the earliest possible moment is the treatment of choice The segment of the intestine immediately proximal to the obstruction usually presents itself in the wound In suitable cases, the gallstone in the intestine should be pushed upward and a transverse enterotomy incision made for its removal proximal to the point of incarceration where satisfactory healing is more likely to occur than if the incision is made directly over the site of incarceration (Fig 102) If possible, it is preferable to push the stone distally and remove it through a segment of bowel that has not been obstructed This however, is rarely feasible If distension is great an enterostomy should be made proximal to the point of incision

Technique of Removal of Stone

The accompanying illustration indicates a satisfactory method of removing a gallstone without spillage—the important desideratum of a successful operation Interrupted sutures of fine silk placed after the mattress pattern of Halsted are placed and retracted with small hooks The incision, transverse to the axis of the bowel is made midway between the near and far side of the sutures When the stone is extruded the sutures are pulled up and a satisfactory closure is obtained A second row of sutures may be placed over the first if it seems desirable to do so When the stone is fixed at the site of its arrest and can not be displaced and the bowel wall overlying it is not viable it becomes necessary obviously to place the sutures farther apart, than one would choose to do for removal of the calculus As is indicated in the insert however this tissue may be trimmed away with scissors before the sutures are pulled up, to close the defect



Fig 103—Photograph of gallstone causing obstruction Removed by operation

In a very obese woman who was also a diabetic the writer failed to excise the gangrenous area, at the site of incarceration of a very large facetted gallstone The inversion left a bowel with a very small lumen

from its site of lodgement A transverse incision is made between the sutures which are pulled aside with skin hooks (B) Placement of sutures and wedge shaped excision of devitalized bowel where stone is impacted and has caused necrosis of the wall (C) Removal of stone The rubber covered clamps and previous stripping of bowel obviate spillage of intestinal content (D) On removal of stone the sutures are pulled up and tied as indicated A single row of well placed Halsted mattress sutures suffices usually to insure satisfactory closure of the defect (See Figs 47A and B for technique of decompressing a distended loop of bowel before placement of sutures)

It became immediately apparent that sacrifice of the large gangrenous patch would have been a wise course *Placement of* an enterostomy tube (No 14F), 15 centimeters proximal to the inversion, sufficed to deal with the situation adequately The stone was facetted, but because the patient was an *exceptionally* poor risk, no attempt was made to ascertain whether another stone was still in the gallbladder The patient wore the enteros tomy tube for two months following dismissal from the hospital No symptoms of another stone having appeared and there being no de monstrable x-ray evidence of a residual stone in the gallbladder, the enterostomy tube was withdrawn There was no leakage and the patient has remained well

Whereas, a large gallstone, which has been drying in a bottle on the shelf for months, may be crumbled with relative ease, it is by no means easy to crush a biliary calculus in the gut The writer tried it once, after proximal displacement of the stone Several thicknesses of gauze were placed over the stone to protect the bowel wall A large Payr type of gastric resection clamp was used The blades of the instrument were sprung badly, but no dent was made in the stone

Mortality

In the 40 cases reported by Gibson, 21, or 52 5 per cent, died In the *series reported by Wolfler and Lieblein, there were 145 cases operated* upon with 82 deaths or a mortality of 56 per cent Wagner found 82 deaths among 175 cases treated conservatively, a 47 per cent mortality, *and 95 deaths among 159 cases treated by the operative method,* with a mortality of 62 per cent It would be extremely difficult however to be wholly certain of the real nature of some of the obstructions in the group *not operated upon* Wortmann *reports 6 recoveries and 1 death in 7 patients* with gallstone obstruction over a 10 year period at the Friedrichshain Hospital in Berlin

There have been no deaths in the last four cases seen in *this clinic,* employing the technique of enterotomy for removal of the gallstone depicted in Fig 102 The persistently high mortality of gallstone obstruc tion has its explanation, in part, in late diagnosis, but failure *to make an aseptic enterotomy is, probably, equally responsible*

No attempt should be made to close the abnormal communication be tween the biliary passages and the intestine at the *time of operation* It is true that many internal biliary fistulas give rise to continued trouble some symptoms and need subsequent operative repair

B INTESTINAL OBSTRUCTION DUE TO FOREIGN BODIES AND FOOD

Children accidentally swallow pebbles, coins, circular whistles, or the like that may give rise to *intestinal obstruction The majority of these* however pass through the intestinal canal without particular event De mented or hysterical persons not infrequently swallow objects of the most unusual character *that lodge in the intestine and obstruct the* bowel Treves enumerates amongst others pins, needles, hooks, teeth, bones, nails, and screws Indigestible materials of small size are likely to accumu-

late until they form huge masses that occlude the intestinal lumen Fruit stones, husks of oats, vegetable fibers, grape skins, hair, wool, and yarn have all been known to be contributory to the formation of such masses Storck Rothschild and Ochsner have reviewed the literature of the subject recently (1939) Hair balls form most commonly in the stomach It is astounding to what size they may attain without causing symptoms—the only complaint being that of tumor A symptomless tumor conforming to the outline of the stomach, on manual palpation is likely to prove to be a hair ball The writer once removed an enormous phytobezoar which filled the stomach of a young girl In her convalescence she stated that the sense of satiety on eating had not been reached earlier when the hair ball was in it The small bowel cannot accommodate itself as readily to the presence of such a body but fortunately lodgement of hair balls in the intestine is unusual Obstruction through this agency does occur

The late J B Murphy recorded an instance in which he recovered a large mass from the lower ileum in a case of intestinal obstruction which he identified as plum pudding, eaten by the patient years previously Beer reports an instance in which Kirschner removed a Murphy button causing bowel obstruction, ten years after gastrojejunostomy The central canal of the button had become plugged by the core of a pear Kloiber removed a Murphy button for a similar cause nine years after gastrojejunostomy Kelling reports removal of a Murphy button from the intestine fifteen and one half years after gastrojejunostomy in one individual and another after twenty years The writer once encountered one accidentally in the bowel during laparotomy, which was believed to have passed, six years after gastrojejunostomy had been made Obstruction was not present

During the hunger period of the World War in eastern Germany and Russia several cases of intestinal obstruction were observed due to the accumulation of the husks of oats in the intestine Brizke and Tigi have each reported a number of such instances some of which caused perforation and peritonitis owing to the impaction of huge masses in the intestine Tigi has placed 36 ca es of intestinal obstruction of this sort on record and described the condition as 'oats ileus' 4 were fatal Many of the patients had eaten whole unground and uncooked oats Millbourn recently reported 5 cases of bowel obstruction due to the ingestion of dried cooked fruit Bran ingested in large amounts has been known to cause bowel obstruction (Davis) Havens (1939) reports fatal plugging of the intestine with colloidal aluminum hyd oxide after 7 days of intra gastric gavage—a treatment employed to control the pain of ulcer, oc casionally

C INTESTINAL OBSTRUCTION DUE TO ENTEROLITHS

Enteroliths are seen very infrequently in man but occur commonly in the intestinal tract of horses The occurrence of enteroliths in the human vermiform appendix is of course a matter of general knowledge Their presence there is a sign of appendical stasis and obstruction Enteroliths that cause intestinal obstruction may be divided into three classes (1)

true enteroliths, (2) mixed enteroliths (phytobezoars), (3) intestinal concretions due to the ingestion of medicaments



Fig 104—Retention of barium in diverticula of the small intestine The patient was subject to attacks of pain and vomiting (See Fig 105)

True intestinal stones usually present a small nucleus which may consist of intestinal epithelium, a small fecal mass, fruit stone, gall stone (Graham), or other foreign body about which alkaline mineral salts of phosphorus, calcium, magnesium, or ammonium may be deposited The stones occur only in the presence of stasis and in an alkaline medium, therefore they are found with predilection in the large intestine and occasionally in the terminal ileum Their occurrence in diverticulas along the mesenteric border of the intestine has been repeatedly noted Watson and Ferry and Mugler have reported recent cases Halstead and Bettmann and Blum have reported enteroliths impacted in Meckel's diverticulum Mixed stones form usually with a nucleus of the husks or peelings of fruits as their nucleus Intestinal contents are then deposited about them in the alkaline medium of the lower intestinal tract They are especially likely to be found in the cecum or terminal ileum



Fig 105—Excised segment of small intestine with sacculations Though the continuity of the intestinal canal was interrupted the handicap to complete evacuation had caused the bowel wall to become considerably hypertrophied

Winterstein has reported the instance of a patient successfully operated upon sixteen years previously for carcinoma of the colon At the site of anastomosis, a stricture developed, proximal to which approximately 1400 foreign bodies, *principally fruit stones and particles* of cellulose had accumulated Incrustation with phosphorous and calcium salts had converted these masses into enteroliths which caused fatal intestinal obstruction

Following the prolonged ingestion of calcium, magnesium, bismuth, and salol, intestinal stones may form In painters and shellac workers the development of such stones has *also been observed*

The clinical features of enteroliths that cause intestinal obstruc-

tion are not unlike those of intestinal obstruction due to gallstones or other foreign bodies in the intestinal tract Many are opaque to the x rays What was said concerning the surgery of gallstone obstruction obtains here also Kelly reported resection of a segment of jejunum for recurrent obstruction, there were three enteroliths in the loop

D INTESTINAL OBSTRUCTION DUE TO WORMS

Intestinal obstruction caused by impaction of worms in the intestine has occasionally been observed Kiesselbach reports the instance of a 15 year old girl who was taken suddenly ill with abdominal pain and in whom a diagnosis of intestinal obstruction was made The patient seemed ill out of proportion to the mechanical effects present At operation, a loop of small intestine with a reddened serosa and dilated bowel was found Palpation of the bowel demonstrated the presence of worms an incision was made and 62 ascarides were extracted

Rost has isolated from worms that inhabit the intestinal tract, a substance that exhibits a marked stimulating effect on the tonus of the intestine of the cat Herrick and Emery isolated a substance from an extract of Ascaris which increased the tone and rate of contraction of intestinal musculature Instances of obstruction in which the accumulation of worms failed to mechanically block the lumen have been reported, in these instances, it has been felt that the liberation of a toxic substance from the worms occasioned spasm of the bowel with ensuant symptoms of intestinal obstruction

The Ascaris is usually the offending agent and its ova may frequently be demonstrated in the stool Most instances of obstruction due to worms have occurred in children Instances have been reported in which the symptoms of obstruction occurred following the institution of vermifuge therapy Ascaris infestation in tropical and subtropical climates appear to be frequent

In a comprehensive paper upon the subject of bowel obstruction due to ascariasis Hoffman relates four types of obstruction with the following incidence

TABLE XXXV—TYPES OF OBSTRUCTION AND INCIDENCE CAUSED BY ASCARIASIS

1 Obturation	65 cases
2 Intussusception	17 cases
3 Spastic	11 cases
4 Volvulus	6 cases

The disease apparently does not occur in nurslings but has its greatest incidence in childhood between the second and ninth years of life It has been observed as late as the sixtieth year In a group of 38 cases Schloeszmann found multiple areas of worm obstruction in 12—usually not less than three The lower ileum is the most common site for impaction of the worms

Clinical Features

Obstruction may be acute or chronic a tumor and visible peristalsis are frequently encountered in the latter variety Tenderness and fever are

usually absent The patient *frequently appears ill out of proportion to the* grade of obstruction, as indicated by the distension present Apathy, somnolence, unconsciousness, and convulsions have been reported The ova may frequently be demonstrated in the stool, vomiting is usually a prominent feature in the acute cases—the vomiting of an Ascaris serves to establish the diagnosis (Levin and Porter) Laurell Archer and Peterson and others have made the diagnosis of ascariasis following the oral administration of barium If barium is given after a period of starvation, the Ascaris also ingests barium, if films are made at one, two, and four hours after the administration of barium, it can frequently *be visualized in the intestinal canal of the Ascaris* (Fig 107)



Fig 106 —Ascarides causing acute intestinal ob truction 8ol worms were removed by enterotomy and 48 were later recovered *per os* and *per anum* (Levin and Porter Brit J Surg 11 432 1923 24)

Treatment

Frequently the nature of the true obstruction will be a surprise finding at operation—the worms being felt through the bowel wall If the obstruction is in the terminal ileum, it is well to try to slide the packet of worms into the colon Of 34 cases of Ascaris ileus treated medically, Hoffman reports death in 24 or 70 5 per cent Of 23 subjected to operation and subsequent medical treatment, 4 died, a mortality of 17 5 per cent In the removal of Ascaris by enterotomy, it is to be recalled that after incomplete removal, the Ascaris may crawl through the suture line and so give rise to peritonitis This occurrence has been noted *after gastrojejunostomy (Plew) and after gastric re ection* (Hofmeister) Genser has reported a case where, on withdrawal of the drain 23 days after appendectomy, an Ascaris came away with it Recovery has been reported after resection of the segment concerned (McLean)

The accompanying table summarizes the operative procedures and the results in 23 surgically treated cases reported by Hoffman

Table XXXVI —Mortality of Operation for the Relief of Obstruction Due to Ascariasis

	Total	Died	Recovered
1 Laparotomy	1		1
2 Laparotomy with pushing a part of impacted packet of worms through bowel wall	3		3
3 Enterostomy without removal of worms	2	1	1
4 Enterostomy and removal of worms	16	3	13
5 Nature of procedure undetermined	1		1

Following convalescence after operation, treatment with vermifuge is important to establish cure Santonin and oil of chenopodium are most effectual Hoffman recommends the oral administration of 8 to 15 drops (depending on age) of santonin in two doses with a two hour interval in the morning Two hours after the last dose, half an ounce of castor oil is given If it is believed that adult forms of the Ascaris are still present, the same treatment should be repeated on the following day

Because of the nature of the life cycle of the worm, it is apparent that many administrations may be necessary to rid the patient of the infestation The life cycle of Ascaris, worked out on rats was first described by Stewart in 1916 and is briefly as follows The ova from polluted soil are ingested and hatch in the small intestine of man The larvae then migrate through the intestinal wall and enter the circulatory system and are carried to the capillaries of the lungs In the pulmonary alveoli, they develop, ascend the bronchial tube and are swallowed After being liberated from the lung the Ascaris attains maturity in the intestinal canal in six weeks



Fig 107—Demonstration of ascaris by roentgen examination The patient ingests barium after a period of starvation (overnight) and the ascaris also ingests the barium into his intestinal canal making visualization of the worm possible (Archer and Peterson J A M A 95 1819 1930)

E INTESTINAL OBSTRUCTION DUE TO MECONIUM IN THE NEWBORN

Forrer described the occurrence of intestinal obstruction in the newborn due to thickened meconium in a Strassburg dissertation in 1895 Landsteiner, in 1905, again called attention to the possibility of this occurrence Bullowa and Brennan described a case in 1919 thinking it the first case of the kind reported

Exalto in 1925 described the instance of a child three days of age who came for operation because of vomiting and other signs of intestinal obstruction no meconium having been passed At operation the nature of the obstruction was not determined and operation was desisted in because of the poor condition of the infant At postmortem, many loops of small intestine were found dilated, the large bowel was empty In the terminal ileum many small whitish yellow plugs adherent to the mucous membrane and not easily loosened from it were found When unrolled they appeared like long flat casts of bowel wall These casts consisted largely of mucus epithelial cells and calcium carbonate Adamson (1939)

and Hild (1939) report meconium obstruction in an infant of 36 hours and state that 22 cases have been reported in the literature

Fanconi has also described a similar instance of a large fecal mass of meconium obstructing the lower ileum The child lived almost three days and the postmortem examination showed thick meconium in the terminal ileum The author postulated a lack of normal bile flow into the intestine had contributed to the solidity of the intestinal content

Mracek found in such a case inflammatory changes in the bowel wall, liver, and pancreas, and felt that these contributed to the thickened meconium

Sara Meltzer recently reported an instance of meconium ileus in which a rent was found in the bowel, on postmortem examination, at the hepatic flexure No meconium was present in the bowel beyond the splenic flexure, but the lumen was apparently normal Kornblith and Otani relate a similar occurrence in which two perforations were found in the ascending colon At autopsy, obliteration of the duct of Wirsung in the pancreas was also found The authors suggested that the lack of pancreatic ferment in the bowel had been responsible for thickening and inspissation of the meconium Instances of this sort have been described in the older literature Zillner related 4 cases in 1884, in which perforation of the pelvic colon had occurred He discussed the possibility of tension perforation of the bowel due to competency of the ileocecal valve as described by Heschl in 1880 and dismissed it, concluding that it was an accident incident to passage of the infant through the parturient canal Paltauff, Sury, Fischer, and others have described similar occurrences

This phenomenon is well known in obstruction of the colon in adults and occurs occasionally as well in imperforation of the anal canal or rectum in newborns In the chapter on spastic ileus, obstruction through the agency of spasm in the pelvic colon is described, in Hirschsprung s disease, release of the spasm of the intestinal musculature by sympathectomy not infrequently does away with the fecal stasis It is not unlikely that many instances of so called meconium ileus more properly belong in the category of spastic ileus

Perforation of the ileum and of the jejunum in the newborn have also been reported, the etiology of which remains obscure (Generisch, Markowitz and Loar)

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CHAPTER XV

FECAL OBSTRUCTION OF THE BOWEL (HIRSCHSPRUNG S DISEASE, MEGACOLON, CONGENITAL IDIOPATHIC DILATATION OF THE COLON)

A PATHOGENESIS

THE most frequent cause of fecal obstruction of the bowel is congenital enlargement of the colon and rectum The first complete description of the disease was given by Hirschsprung in 1886 and since then the disease has been known by his name

The typical variety of Hirschsprung s disease begins early in infancy with progressive difficulty in obtaining satisfactory bowel movements The abdomen enlarges and the sigmoid loop of the large intestine can frequently be made out over the abdomen The bowels may not move for days and in the series of cases reported from Mendoza in the Argentine by Corbin where the condition is said to be prevalent in adults, evacuations may not obtain for weeks at a time Over a period of 22 years Corbin writes that 200 such cases of megarectosigmoid have come under his supervision When the condition makes its first appearance in adult life, it is usually described as pseudo megacolon Many theories have been advanced as to the cause of the disease among which may be mentioned mechanical neuropathic, inflammatory and congenital abnormalities Barrington Ward has pointed out that abnormalities are frequent in the hind gut and believes that a number of these cases have their origin in such an explanation

David has reported 3 cases of megacolon in infants in which a stricture of the rectum was present and reference has already been made to 6 such cases reported under the heading of incomplete rectal atresia by Brennemann (p 184) Rectal stricture apparently is a common cause of megacolon

A number of years ago Perthes observed in a patient upon whom he had performed a colostomy for congenital enlargement of the colon and rectum that fluid administered by rectum came out of the colostomy with ease whereas when given from above it appeared to be retained and did not enter the rectum Examination showed that the mucous membrane folds of the upper rectum caused a mechanical block following division of these folds marked improvement ensued Lawen and Gant have also treated patients with congenital megacolon by division of Houston s folds with apparent success

The motor nerve of the intestine is the vagus except for the sphincters of the bowel at the pylorus, ileocecal valve and O'Beirne s sphincter at the juncture of pelvic colon and rectum The sympathetic influence it is felt regulates motor activity at all of these points The fibres of the vagus however have only been traced as far as the right half of the colon It has been suggested that failure of normal relaxation of the sphincter at the

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distension was so great as to lead to perforation and peritonitis In some cases an associated tuberculous peritonitis brings about the presence of fluid in the peritoneal cavity The essential pathologic changes in the bowel are hypertrophy and dilatation The bowel may assume enormous proportions

C CLINICAL FEATURES

A large protuberant abdomen and a history of difficulty in defecation usually establish the diagnosis without much difficulty X ray examination of the abdomen employing the scout film shows mottled shadows owing to fecal accumulations Fecal masses can usually be felt through the abdominal walls Emaciation is frequent Despite the large accumulation of fecal material in the bowel, a history of vomiting is rarely obtained even in the presence of acute intestinal obstruction The accompanying illustration indicates the degree of dilatation of the sigmoid flexure in a boy of three with congenital megacolon (Fig 109) Difficulty with evacuation of the bowel may start with birth or may only become apparent later Dyspnoea, circulatory embarrassment and compression of the ureter with ensuant hydronephrosis have been observed in the course of the disease (Rankin) If any doubt exists concerning the nature of the abdominal enlargement, the administration of a barium enema or careful inspection of the scout film of the abdomen will serve to set the examiner aright

D TREATMENT

No treatment is wholly satisfactory In the presence of acute intestinal obstruction, colostomy is the method of choice These cases constitute a serious surgical problem because the removal of a single fecal tumor and the reestablishment of the continuity of the intestine do not rid the patient of his disease Even excision of the enlarged colon does not insure permanent relief Where the disease is confined largely to the pelvic colon primary resection with reestablishment of intestinal continuity by oblique end to end anastomosis is the procedure of choice When the entire colon is involved complete extirpation with anastomosis of the terminal ileum to the supraperitoneal portion of the pelvic colon as recommended by Mirizzi though a formidable undertaking is the only hope for complete relief The writer has performed this type of operative procedure successfully in a few patients with multiple neoplasms in the colon A persistent fecal fistula on the abdomen of course will also free the patient from his intestinal stasis in Hirschsprung s disease

The results reported after sympathectomy for idiopathic dilatation and hypertrophy of the colon have been most encouraging and are, without doubt, the best which have been obtained to date Rankin and Learmonth have suggested division of the presacral nerve as a satisfactory substitute for the bilateral lumbar sympathetic ganglionectomy of Adson It is questionable however whether the results from this procedure warrant the substitution In the procedure of Adson as well as that of Royle, the sympathetic influence to the lower extremities is removed as well—to be certain an unnecessary but yet not an undesirable feature In patients

juncture of the pelvic colon and rectum may give rise to a mechani obstruction and subsequent dilatation of the intestine above The case which sympathectomy had been performed by Wade and Royle, Ad Rankin, Robertson, White and others suggest that such a mechani may operate in certain cases

Finney, who has given the disease considerable study, inclines to belief that lymphangiectasis plays an important role in the genesis of disease An unusual hypertrophy of all the layers of the bowel, especia

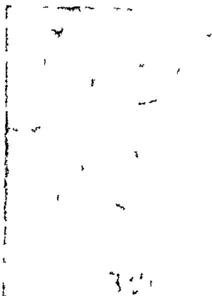


Fig 108—Megacolon in Hirschsprung s disease (There was no mechanical obstruction present) (A W Adson Surgery 1 860 1937)



Fig 109—Sigmoid flexure in a boy three years with congenital megacolo (Hirschsprung s disease)

the muscular layer, obtains In one third of the cases, according to Finney this enlargement is confined solely to the pelvic colon, in 15 per cent, th entire colon is concerned and, in a few instances, portions of the smal intestine have been involved The writer once observed the condition a necropsy upon a newborn—the wall of the entire pelvic colon being con siderably thickened

B PATHOLOGY

Acute intestinal obstruction may at any time be superimposed upon th more chronic picture of *intestinal stasis Volvulus of the sigmoid flexur* in congenital enlargement of the colon is not infrequent (Weeks) The ob struction is of the simple variety in most instances, fecal accumulation in the bowel causes a progressive dilatation of the entire intestine above The accumulation of feces in the bowel may frequently lead to a complete mechanical block Berry has reported the instance of the accumulation of hard fecal masses in the bowel causing intestinal obstruction in which the

distension was so great as to lead to perforation and peritonitis In some cases, an associated tuberculous peritonitis brings about the presence of fluid in the peritoneal cavity The essential pathologic changes in the bowel are hypertrophy and dilatation The bowel may assume enormous proportions

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who are poor risks, the retroperitoneal unilateral procedure of Royle is best borne Resection of the left ganglionic chain and of the presacral nerve is occasionally quite adequate Adson (1937) has reported the late results in a group of cases of Hirschsprung's disease treated by sympathectectomy In the main, the results were very gratifying Scott and Morton suggest taking x ray films following the administration of a barium enema, spinal anesthesia is then induced and roentgen films are again made A favorable result may be expected to attend sympathectomy if the film following spinal anesthesia shows considerable reduction in calibre of the colon

In a recent communication, Adson (1941) states that he has been employing, *largely, the same type of sympathectomy* which he has used to advantage in the surgical management of hypertension A bilateral subdiaphragmatic approach is employed through which the splanchnic nerves are resected, a portion of the celiac ganglion removed and the upper two lumbar ganglia This procedure, according to Adson, interrupts the sympathetic fibers which descend along the colon and enter the presacral plexus of Haveloeque as well as sympathetic fibers which follow the mesenteric arteries to the colon Concerning the results of operation, Adson states

"(1) Sympathectomy of the extensive type, is more effective than the bilateral lumbar, presacral or the intramesenteric sympathectomy

(2) If sympathectomy is to be instituted it should be performed preferably before the fifth year of age, before the intestine enlarges beyond the point of recovery There is no question that, if the intestine continues to dilate and fibrosis and hypertrophy result many of the intramuscular nerve cells of Meissner and Auerbach are de*stroyed, as are the connections with the parasympathetic and sym*pathetic nerves which innervate the bowel, an occurrence which makes neurogenic procedures useless"

With the aid of hot water enemas, Friedell has been able to show upon patients on the pediatric wards of the University of Minnesota Hospitals that, the bowel can be made to contract down in instances of megacolon, assuring more effectual evacuations These daily rectal instillations of hot water should be an integral part of the medical management of such cases

Law (1940) reported successful management of megacolon with mecholyl bromide (acetylbetamethylcholine bromide) Law looks upon Hirschsprung's disease as the result of an imbalance of the autonomic stimuli to the colon Two neurogenic hypotheses are possible to explain the occurrence (1) overactivity of the sympathetic nervous influence, causing inhibition of the colonic musculature with spastic sphincters, (2) diminished toxins of the parasympathetic innervation with resultant ineffectual colonic contraction Since the papers of Law, Barenberg and his associates (1941) have reported striking success with mecholyl bromide in a patient upon whom a previous sympathectomy had been done without effect One milligram of mecholyl bromide is given to start with and with increased tolerance a dose of 200 mg was given twice a day Mineral oil is given until regular bowel movements are obtained

In their recent monograph, Ladd and Gross (1941) state that it is their

impression that parasympathetic stimulants, such as mecholyl bromide have a limited field of usefulness, being especially helpful in the mild cases They emphasize the value of rectal dilators in reawakening the reduced sensitivity of the rectum to distension

White (1941) believes that adequate medical measures, supplemented by the use of mecholyl bromide will take care of most cases satisfactorily, and that, sympathectomy is to be reserved for the refractory cases Adson concedes that some of the patients for whom he has performed sympathectomy have come eventually to partial colectomy The relative safety of extensive colectomy performed as a one stage procedure employing the closed anastomosis in practiced hands, is so well established as to suggest that failure of medical means or sympathectomy is an indication for colectomy

The results obtained by Perthes, Laewen, and others by division of Houston s valves suggest that the condition of these rectal mucosal folds is always to be ascertained on proctoscopic examination

Before any operative procedure of magnitude is contemplated upon a patient with megacolon it is important to get the colon empty It may take weeks before the fecal masses in the colon come away The liberal daily administration of mineral oil by mouth, daily enemas and instillations of oil into the rectum are necessary to bring this about David reports an instance in which 47 pounds of feces were found in the large bowel Colostomy may have to be performed as a temporary expedient Ask Upmark has recently reviewed the end results of a group of cases of megacolon treated in Swedish hospitals over a period of time varying from 1 to 25 years The results in the conservatively treated group were better than in those treated surgically There were however no sympathectomies in the group In a review of the results of surgical treatment, Neugebauer points out that the multiple stage resection (exteriorization of Bloch Mikulicz) commands the lowest mortality Resection of the colon with reestablishment of intestinal continuity fails to cure uniformly for, in a number of instances the rectum also is involved (Ask-Upmark) Neugebauer warns that in opening the abdomen of patients with megacolon, care should be taken of the bladder, for it too may be enlarged Passler (1938) has summarized in a monograph the results of all types of treatment for megacolon

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In those instances where the distension and the obstructive features are great recourse should be had to operation In the accompanying skiagram is shown such an instance (Fig 110) A multiparous woman late in the seventh month of her pregnancy was admitted to hospital because of abdominal pains and distension—the latter was great as evinced by the film (Fig 110) The presence of intestinal colic was readily made out Whether the pregnant uterus compressed the pelvic colon and gave rise to the obstruction, or whether the ileus was spastic in character or due to an intrinsic neoplastic stricture in the bowel could not be ascertained It was obvious however that relief from the distension was necessary to obviate perforation of the bowel The assumption of the knee chest position by the patient did not alleviate the intestinal colic—the thought being that the uterus might be tilted forward by this maneuver A transverse colostomy was done as depicted in Fig 50 The distension was too great to permit examination of the pelvic colon Premature labor was induced by the operative procedure and a viable baby was obtained A barium enema made during convalescence failed to reveal a lesion in the pelvic colon and the glass rod beneath the bowel at the site of the colostomy was withdrawn spontaneously the bowel gradually retracted within the abdomen Fig 111) The abdominal wall is strong and there is no evidence of hernia



Fig 110—Intestinal obstruction during pregnancy The fetus the distended colon and the duodenal tube in a somewhat distended stomach are shown The small intestine was not distended The problem to decide was whether the uterus by compression caused the obstruction or whether spastic ileus of the colon or an intrinsic obstruction (probably carcinoma) was responsible

One can now be certain that there was no intrinsic occlusion in the bowel Whether this obstruction was due to mechanical compression of the uterus or a physiologic spastic obstruction one can not be wholly certain Fatal obstruction due to perforation of the colon, occasioned by an annular carcinoma during pregnancy has been reported A large number of papers have been written upon obstruction in pregnancy That the pregnant uterus near term can compress the pelvic colon is both affirmed and denied In instances of the sort referred to above another alternative would have been to empty the uterus at operation by Cesarean section Should an intrinsic lesion have been present in the bowel however the obstruction would not have been relieved by emptying the uterus alone The simpler operation of colostomy would appear to be the procedure of choice in such instances In the presence of sanguineous fluid in the

CHAPTER XVI

INTESTINAL OBSTRUCTION DUE TO COMPRESSION OF THE BOWEL

A PATHOGENESIS

OBSTRUCTION of the intestine by external compression may occur through a number of agencies Where the bowel is fixed, this type of obstruction is most likely to occur It is most frequently seen in (1) the pelvic colon, (2) the retroperitoneal duodenum, and (3) the terminal ileum at its insertion into the cecum Malignant tumors of the pelvic organs and inflammatory masses in the pelvis most often give rise to intestinal obstruction of this variety The bony boundaries of the pelvis account for the frequency with which this type of obstruction is observed The "plaster of Paris" induration causing colonic compression in para metritis and cellulitis of the pelvis is well known Cysts and solid tumors in the mesentery, wandering spleen, hydronephrosis, tumors of the kidney and the pregnant uterus have been known to cause obstruction of the intestine through this mechanism (Ludwig) Tumors of the mesentery, that fix the intestine, permit the bowel becoming squeezed by a small mass which a larger mass would fail to accomplish, if the bowel were mobile enough to escape The compression of the retroperitoneal portion of the duodenum by the superior mesentric artery may give rise to the so called "arteriomesenteric ileus" The drag of a fat laden mesentery and a heavy bowel over the duodenum may compress the immobile duodenum against the spinal column When the patient lies supine or stands erect, this pull would be greatest As Dwight has pointed out, such an occurrence is not likely in a four-legged animal in which the superior mesenteric vessels would fall forward free from the duodenum

Large retroperitoneal tumor masses as observed in Hodgkin's disease or metastatic tumors of the testis occasionally give rise to intestinal compression in which mechanical and inhibitive (paralytic) effects commonly operate together

B PELVIC OBSTRUCTIONS (PREGNANCY)

These obstructions are usually of the simple variety Compression of the pelvic colon could bring about the effects of an intrinsic obstruction with great increase of intraluminal pressure with consequent threatened perforation of the proximal colon In the main, however, such obstructions are usually incomplete in nature, and they participate in the features of similar intrinsic obstructions of the colon A mass can invariably be palpated In suitable areas the removal of the mass is the operative procedure of choice The difficulty which arises in distinguishing spastic obstruction of the colon from an intrinsic lesion in the colon may also obtain here

D ACUTE GASTRIC DILATATION

It is well to remember that acute gastric dilatation can occur with apparently little cause and may be provoked by a variety of diverse agents It is not uncommonly observed following hyperextension of the spine for reduction of compression fracture of a lumbar vertebra So frequently has this complication attended fixation of the spine in hyper extension in a plaster of paris cast that suction is routinely applied to an indwelling duodenal tube in this clinic to preclude its occurrence,



Fig 112—Acute dilatation of the stomach—largely gaseous A X ray film taken directly after the insertion of the gastric tube and before suction was begun shows the stomach greatly dilated B Film taken after suction had been in force for 2 hours during which time 1000 c c of fluid and 3000 c c of gas had been removed by suction

as soon as the fracture has been reduced Whether compression of the duodenum by the superior mesenteric artery in this hyperextended position has anything to do with the frequent supervention of acute dilatation of the stomach is problematic That this position favors the development of arteriomesenteric ileus is readily apparent In the prone position, the transverse colon and small intestine fall forward and there should be less likelihood of its occurrence After trivial trauma, in uremia, diabetes and other conditions acute gastric dilatation may occur with unaccountably little provocation After thoracoplastic operations on the chest wall, acute dilatation of the stomach occurs, not uncommonly Hurrying of the pulse and quickened and labored respirations attended by great gaseous distension of the upper abdomen suffice to suggest its presence Employment of suction will ordinarily rectify matters in a short time If the nature of the condition remains unrecognized and the distension is not relieved death usually occurs At postmortem the only significant finding may be a stomach tremendously dilated with gas and fluid

Postoperative acute dilatation of the stomach has come to be a rare complication with general employment of suction applied to an indwelling

peritoneum suggesting a *strangulating obstruction*, preliminary emptying of the uterus by Cesarean section probably would be necessary to afford adequate visualization of the nature *of the obstruction* Where compression is due to a radiosensitive tumor, the employment of irradiation accompanied by suction applied to an inlying duodenal tube may suffice *to avoid* operative intervention

C *ARTERIOMESENTERIC* OBSTRUCTION

Vomiting is a prominent feature of arteriomesenteric obstruction and dehydration and dechlorination are likely to attend it The diagnosis is made by the finding on x ray examination of a dilated duodenum Pain is *ordinarily not* a prominent feature Every patient with a dilated duodenum does *not* have *arteriomesenteric* ileus Patients suffering from this disorder are subject to periodic attacks of vomiting



Fig 111 —Spontaneous closure of colostomy after decompression for acute colonic obstruction When a barium enema failed to reveal the presence of an organic lesion in the pelvic colon the glass rod was withdrawn and the bowel retracted *into the abdomen (Photograph* of patient whose x ray film is shown in Figure 110

This condition is probably closely allied to so called acute dilatation of the stomach The persistent vomiting occasionally observed after operation or after the application of a plaster *cast to the* body may have its origin in some such mechanism Suction applied to an inlying duodenal tube and the liberal para oral administration of saline solution will suffice to take care of the acute disorder For those few cases with frequent such periodic attacks, in whom the duodenum can be shown *to be* dilated and no other cause can be ascertained, the operation of duodenojejunostomy, first performed by Staveley, is justified When done on good indication, the results are excellent (Wilkie) The operation of partial colectomy to diminish the pull of the superior mesenteric artery and its mesentery upon the retroperitoneal duodenum would not appear to be justified unless *the simpler procedure of duodenojejunostomy was ineffectual* (Bloodgood)

Since Ladd has pointed out that cases of extrinsic obstruction of the duodenum are due to adhesions and may be relieved by their division, duodeno jejunostomy, for o called arteriomesenteric ileus, is performed relatively infrequently Undoubtedly many patients operated upon for arteriomesenteric ileus have had the syndrome of Ladd of extrinsic compression of the duodenum by adhesions *Intrinsic duodenal obstruction* (duodenal stenosis) presents a proper indication for duodeno jejunostomy —a *condition* that is relatively infrequent as contrasted with extrinsic compression

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catheter during the early postoperative period Yet, the potential for its occurrence is ever present A frequent cause of shock, in debilitated patients, is the fluid loss and hypochloremia of acute gastric dilatation In experienced house officers are not likely to think of this complication as a possibility when called to the wards to see a patient in shock, drenched with perspiration and exhibiting a thready, hurried pulse, depressed arterial blood pressure and cold extremities A more seasoned observer is often able to make the diagnosis of acute gastric dilatation in such instances over the telephone in the absence of any external hemorrhage or likely source for internal bleeding much to the dismay of the surprised house officer Aspiration of the stomach and the liberal intravenous administration of physiologic saline solution in such instance, will quickly revive such patients, much in the manner that water will restore the bloom to wilting flowers

Acute dilatation of the stomach may present itself in two forms (1) The mechanical compression syndrome, occasioned by the collection of a large amount of gas in the stomach (Fig 112) This occurrence may be observed in any patient in the early convalescent period and may accompany injury of varying sorts (2) The dehydration and dechlorination syndrome occurring usually in debilitated patients, causing severe contraction in the blood volume with the resultant picture of shock described above Surprising amounts of fluid and gas may be aspirated from the stomach in such instances—necessitating change of the suction bottles, each with a 4 liter capacity, before the distension is gone

It is strange that such patients have frequently no vomiting However, the upper left quadrant of the abdomen is distended invariably and quite tympanitic on percussion, usually Alert, experienced surgical nurses familiar with potential complications which may arise on a surgical ward, aid often in directing attention to the possibilities of this occurrence, while there is still time to do something about it

Patients with obstruction at the pyloric outlet from a duodenal ulcer, and even patients with gastric malignancy with pyloric obstruction may be admitted to the emergency ward exhibiting this syndrome of dehydration and dechlorination In such instances, the vomiting tells the tale and the cause is obvious In the cases with acute dilation of the stomach, exhibiting the very same effects with gastric retention but no vomiting the complication is not identified so readily Moreover, the causes which operate to bring the situation about are frequently obscure or wholly inexplicable

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Chapter XVII

INTESTINAL OBSTRUCTION DUE TO ADHESIONS AND BANDS

A PATHOGENESIS

In every series of cases of intestinal obstruction, this group constitutes a fairly large proprotion of the total Of 368 cases of intestinal obstruction reported by Flesch Thebesius from the Surgical Clinic at Frankfurt, 162, or 44 per cent, were due to adhesive bands Guillaume found amongst 400 cases of intestinal obstruction that 125 cases owed their origin to this agency There is uniform agreement that most adhesions causing intestinal obstruction develop after operation Of 162 cases of adhesive ileus reported by Flesch Thebesius 113 cases had previously been operated upon In cases of adhesive obstruction following operation appendectomy is the most frequent cause of subsequent intestinal obstruction, a large proportion have usually required drainage—44 per cent in the series of Deaver and Ross Operations on the female pelvic organs rank second as the precursor of postoperative adhesions causing obstruction It is an interesting fact that there appears to be no direct correlation between the location or presence of the adhesions and the development of intestinal obstruction

Bryant in performing 297 routine postmortem examinations with the point in mind of determining the occurrence of adhesions, found that the transverse colon in both male and female was most frequently involved Next in frequence, adhesions were found around the gallbladder duodenum, omentum, ascending colon, hepatic flexure appendix, liver and descending colon

Adhesions that give rise to intestinal obstruction may be of congenital origin as the avascular fold that binds the terminal ileum to the cecum Peterson has devoted an entire monograph to this type of obstruction which he has dignified by the designation 'ileus ilei terminatus fixati" Adhesions may form al o in consequence of external blunt trauma or following intraperitoneal hemorrhage and other inflammations of all varieties and following tumor implants in the abdomen Adhesions after endometrial transplants in the pelvis are not infrequent The adhesive type of tuberculous peritonitis commonly causes chronic intestinal stasis and occasionally acute intestinal occlusion Muller and Rademaker stress the item of infection as being important in the genesis of all adhesions Kaufman classifies adhesions as postoperative and spontaneous and recognizes amongst the latter division, traumatic congenital and inflammatory Many discussions as to whether adhesions are congenital or acquired have generated more heat than light

Adhesive bands may cause obstruction by actual compression of the bowel through traction and kinking of the intestine or by effecting a

volvulus or strangulation of the bowel Meckel's diverticulum may give rise to obstruction by any one of these mechanisms Bands causing intestinal obstruction usually concern the small intestine, when the large intestine is involved, the flexures of the colon are usually implicated—the hepatic, splenic, and sigmoid flexures Colonic obstruction by adhesions is usually due to compression, such as a band running from the stomach over the transverse colon becoming adherent to some other fixed point In the experience of the writer obstruction of the colon is rarely brought about by adhesive bands Buermann believes that pericolic bands overlying the right colon may cause pains, simulating appendicitis McCann has described recently instances in which he believes that the omentum gave rise to colonic fixation and obstruction The bands may be narrow, representing mere threads or they may be broad peritoneal folds In the 125 instances of adhesions reported by Guillaume, 65 cases were of the former variety and 60 of the latter type

Intestinal obstruction through the agency of adhesions may occur at any time after operation Of the 113 cases of postoperative ileus in the series of *Flesch-Thebesius, 69 followed appendectomy Of these,* 25 cases developed in the first four weeks after operation, 20 others occurred within the first year, 8 in the second year, 5 in the third year, 5 in the fourth and fifth years, 5 in the sixth to tenth years, and one occurred later In the cases of Deaver and Ross, the average time after operation for the development of obstruction was two years and three months Foreign bodies left in the peritoneum are a great stimulus to the formation of adhesions which may cause obstruction

B PATHOLOGY

Adhesive bands may give rise to either a simple intestinal obstruction or to the strangulating variety The more frequent occurrence is the simple occlusion of the lumen by compression, kinking or traction Volvulus is not infrequent through the medium of abnormal bands in the peritoneal cavity Wilms has described this variety of intestinal obstruction in considerable detail under the special caption of "Knotting of the Small Intestine" Kallio has recently devoted a monograph to this particular variety of obstruction which he found more frequent in Finland than elsewhere In those instances in which the vitello intestinal duct persists as Meckel's diverticulum in the adult and especially where the obliterated vitelline vessels run out to the umbilicus as a cord like structure such bands may not infrequently give rise to strangulation or kinking of a loop of the intestine In the postoperative period, particularly if distension is present fibrinous adhesions and inflammatory processes are likely to kink and *obstruct the* bowel The same holds true of conditions arising spontaneously in which the presence of blood or pus in the peritoneal cavity brings meteorism about and at the same time gives rise to the formation of fibrinous adhesions The writer once observed the occurrence of adhesive obstruction through the agency of hematoma formation occasioned by torsion of aberrant (accessory) splenic tissue

C CLINICAL FEATURES

The symptoms of adhesive ileus vary within the widest possible limits, depending largely upon whether the obstructive mechanism is simple in type or of the strangulating variety It is also obvious that varying grades of both types may be present Intermittent crampy colicky pain is usually the patient s first complaint Nausea and vomiting soon follow Tenderness is not present unless the adhesive band becomes adherent to the abdominal wall exerting traction on the parietal peritoneum if an intestinal loop is strangulated, sanguineous fluid escapes into the peritoneum producing tenderness

The history of a previous operation is often very significant in arriving at an opinion In such instances frequently the diagnosis can be made over the telephone as the late Lord Moynihan characterized the case of recognition of typical cases of duodenal ulcer When the surgeon is informed that his patient is suffering from gas pains and that nausea and vomiting are prominent features that the abdomen is distended but not tender and that minor disturbances of a similar sort have been present now and then since an appendectomy or hysterectomy performed a few years ago the surgeon should suspect bowel obstruction It is not to be forgotten however that adhesions may obstruct and strangulate the bowel in the absence of abdominal operative scars



FIG 113—Adhesions demonstrated by inflation of carbon dioxide into the peritoneal cavity This procedure was done after relief of acute intestinal obstruction by enterostomy

Richardson has stated that 2 per cent of the patients having suppurative appendicitis requiring the employment of drainage upon whom he has operated have had pain of an obstructive character during their convalescence Grey Turner states that out of 2500 operations for appendicitis 45 cases or 1 9 per cent subsequently develop acute adhesive obstruction of the small intestine

D DIFFERENTIAL DIAGNOSIS

That mechanical obstruction is present is the most important thing to decide To be certain one can rarely be wholly certain that the obstruction is due to an adhesive band or multiple adhesions In the distension occurring early in the postoperative period a functional obstruction has to be excluded The stethoscope affords the most reliable evidence in this differential A mechanical obstruction without *intestinal colic* does not exist The x ray film also lends important information when correlated with the clinical findings In typical instances, the roentgenologist fre-

quently can tell whether the obstruction is mechanical or fun (paralytic) Intestinal distension, however, is subject to so many v that interpretations, made on the basis of the extent of the in distension and the conjectured absence or presence of fluid betw distended intestinal coils as viewed on the x ray film are open to errors When a loop of bowel has been imprisoned beneath an a band for some time, the picture of stenosis may appear—palpab visible peristalsis of the hypertrophied and distended loops of gu in evidence In such instances, the diagnosis of neoplasm of the intestine is made usually

The development of a mechanical obstruction during convale from operation is, it is true most likely to be due to adhesion form However, the presence of a potential obstructing agency, not prev recognized, such as a carcinoma of the bowel, must always be thou Volvulus has *occurred during the convalescence from operation* H tion of the gut into the lesser omental bursa after gastrojejunosto beneath the jejunal limb, leading to and away from the stoma or a the fixed colon after colostomy have been reported Such accident be kept in mind in deciding upon the nature of a postoperative ob tion Multiple obstructions have been described (Finsterer, Block, Sel fer, see p 439)

E TREATMENT

Early recognition is the best treatment A large number of obstru due to adhesions will respond to suction siphonage This is partic true of the partial obstructions and those occurring as a complicat an accompanying inflammatory process The application of hot pa the abdomen and the administration of hot douches and enemas a value in hastening the resorption of inflammatory masses Adhesiv *structions occurring during convalescence from an antecedent abdo* operation almost uniformly yield to suction As has been pointe (p 169), the avoidance of distension during the early postoperati riod by the routine employment of suction in those instances wher occurrence of distension is to be anticipated, will very materially r the incidence of the postoperative mechanical obstructions The ins tions outlined on page 153 should be carefully followed in the conserv *management of such cases*

In the patient whose obstruction needs relief by operation, the ge status of the patient and the local abdominal physical findings sh guide the surgeon A strangulating type of obstruction calls for a ploratory vertical incision and determination of whether the bow viable *For the late simple obstruction, enterostomy* is the operati choice, in the early simple obstruction the operation of election ma done with deliberate search for the point of obstruction Summer's s will invert satisfactorily a small damaged area of bowel beneath a stricting band (Fig 114) A single adhesive band is dealt with much easily than multiple ensnarling adhesions *In the instance of the for* simple division is in order, in the latter, a note of warning is to be sou against the direct attack of attempting their release Frequently the suspecting surgeon is lured on by the chase of adhesive bands, like

innocent children of Hamelin were carried off by the Pied Piper, until he finds that there is no retracing his steps He has enmeshed himself in the entanglement and escape without doing harm may be unlikely Too often the bowel is opened, which accident in the presence of obstruction usually spells doom for the patient A simple enterostomy in such instances will save the surgeon considerable difficulty and multiply the patient's chances of recovery Should the enterostomy vent prove to be the only avenue of escape for intestinal content and the intestinal lumen below continue

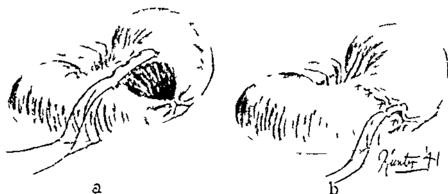


Fig 114—Method of inverting a small gangrenous area in the gut wall (so called Summers stitch) (See also Fig 102 illustrating technique of removal of gallstone) (a) Placement of Halsted mattress sutures It is to be noted that the suture at either end is what the writer describes as the 3 2 stitch That is in order to insure satisfactory closure at the ends the stitch going takes 3 bites of tissue and 2 returning This 3 2 stitch takes the place admirably of a semi purse string suture and one can predict reasonably the character of the inversion which attends its use (b) The suture completed

obstructed a subsequent attack will have to be directed at the obstructing agency When the patient exhibits definite improvement from the decompression such a succeeding procedure when feasible should be release of the gut from the entangling adhesions occasionally however an entero anastomosis or even resection of this segment of gut will have to be made In the main entero anastomosis is a safer procedure The warning uttered by Estes and Holm and Pearse and others relating to distension of such a side tracked loop must be borne in mind Usually however, in adhesive obstructions as well as in stenosis demanding an entero anastomosis though a sufficient lumen does not exist for drainage of the entire intestinal current the shunting accomplished by the lateral anastomosis enables the lumen of the obstructed gut to drain this short segment of bowel adequately There is an occasional case of obstruction due to a single adhesive band, in which the performance of "blind enterostomy"

does not suffice to deal with the situation Despite the decompression of *the distended bowel by the enterostomy* catheter, the adhesive band may cut into the lumen of the bowel, causing leakage and peritonitis The writer has had such an experience The potential for this occurrence suggests the necessity for developing means, whereby the bowel can be decompressed safely at operation It was just such an experience which suggested to the writer the elaboration of a safer method of emptying the bowel at operation than is afforded by the Monks Moynihan evacuating tube Diminution of the distension, brought about by removal of the contents of distended intestinal loops in the vicinity of the obstruction, permits accurate identification of the nature of the obstructing mechanism and enables the surgeon to determine the safest choice of procedure in dealing with the band Aseptic decompressive suction enterotomy (see Fig 53B) constitutes a satisfactory means of dealing with the distension in such instances Simple enterostomy is a good operation, but it does leave *a good deal to chance, occasionally*

In this clinic, a number of partial enterectomies have been done upon patients, in an unobstructed phase, for recurrent obstruction, due to adhesions *It is often the best solution for the patient, presenting an enlarged* snarl of adhesions and who has been obstructed several times (see page 211)

When operating for adhesive obstruction, the site of a previous operation should be carefully inspected in suitable cases It is wise to select a fresh area over the abdomen for the incision Too frequently the gut is adherent to the abdominal wall immediately below the old scar The presence of hemorrhagic fluid suggests the necessity of looking for a strangulating obstruction Rarely a simple obstruction may cause sanguineous fluid to accumulate in the peritoneal cavity The surgeon is never disappointed upon completion of his search to find that the obstruction is simple in character When circumstances permit and occasion demands it a routine examination of the entire small intestine must be made to rule out an obscure but persistent band which may prove a menace later

The tendency to formation of peritoneal adhesions appears to be in some measure an individual factor Occasionally they form in abundance after so-called clean" or interval operations and in other instances may fail of being demonstrated after fairly diffuse peritonitis Intraperitoneal ligations ' en masse the introduction of chemical irritants and the use of too hot abdominal packs predispose to their occurrence Horne believes that adhesive ileus is much more likely to follow when drainage is established through midline or rectus incisions Encirclement of the drainage tract by loops of the intestine is much more likely Horne states than when lateral drainage is established Following pelvic operations, a definite attempt should be made to peritonealize all raw areas, the sigmoid flexure often serves this purpose well

Operation is well deferred when feasible in patients presenting the effects of a simple adhesive obstruction who are convalescing from a peritoneal infection, such as peritonitis attending rupture of the appendix Too often, exploration, enterostomy or any procedure, succeeds only in spreading the infection, thereby intensifying the obstructive element Suc-

tion applied to an indwelling duodenal tube, if effectual is usually the best attack upon the obstruction in such cases Nevertheless, the surgeon must bear in mind in such instances, the possibility of a strangulating obstruction, which must not be treated by suction alone Some of the difficulties which hedge about this problem have been discussed previously (p 115)

In this clinic, two women presenting intestinal obstruction, occasioned by plastic pelvic masses, were treated successfully by a combination of suction and the application of external heat with the Kettering hyper thermic apparatus (Smith) The improvement in both instances was striking This agency may prove helpful in deferring the necessity for opera tion in plastic inflammatory masses

Prevention of adhesions

The formation of intraperitoneal adhesions is a reparative process in response to injury of a serous surface The problem as it relates to adhesions is not so much one of prevention as of limiting this process of repair during the healing stage to the injured endothelial membranes Of the large number of substances that have been recommended to prevent the formation of adhesions and have been given adequate clinical trial very few have withstood the test of time Essentially four types of agents have been employed to obviate excessive intraperitoneal adhesive forma tion (1) The application of greasy or oily substances over the denuded peritoneal surfaces, such as liquid paraffin, vaseline or acacia The testimony of experimental evidence would indicate that these remedies stimu late rather than prevent the formation of adhesions (2) The administration of drugs such as eserine, pituitary extract prostigmine and others to augment intestinal activity in the immediate postoperative period (3) Introduction of dilute solutions of tissue digestants such as pepsin trypsin or papain into the peritoneal cavity (4) The use of fluids which are slowly absorbed from the peritoneum In the ascitic variety of tuberculous peri tonitis adhesions are rarely seen Saline and sodium citrate solutions are absorbed too quickly to be of any great value in floating the intestinal coils apart during the healing period Amniotic fluid has been used for this purpose with varying results by a number of investigators Rea and Wangensteen found a 1 per cent solution of sodium ricinoleate (soap solu tion) more effectual experimentally than amniotic fluid defibrinated blood, or air Lehman and Boys (1940) find that heparin destroys and inhibits fibrin formation when placed in the peritoneal cavity They believe that heparin may come to play an important role in preventing adhesion formation

It is difficult to appraise the true value of clinical reports which indi cate the lessened incidence of bowel obstruction due to adhesions following the use of one agency or another In assaying the value of any method a crucial test is pre ented by those patients who are adhesion formers ' The writer's experience with a limited trial with anti adhesive agencies in such patients would indicate that too much optimism has been expressed by many writers concerning the prevention of adhesions

There are a group of patients who have had a long series of abdominal operations for adhesions and bowel obstruction which present a very

difficult problem In recently looking up the cases of this nature which the writer has treated, it was found that the majority of them were morphine addicts—probably made so by a low tolerance to persistent pain It appears to the writer that morphinism is probably an important factor in the difficulties of these patients Some of them have come in complaining of gas pains and vomiting when gaseous distension of the small intestine was absent altogether or scarcely recognizable in the roentgen films Constipation has usually been an important feature as well and it has been difficult to escape the impression even though intestinal colic could be demonstrated that the functional element was not perhaps even as important as the adhesions Some of these cases are undoubtedly closely allied to so called functional spastic ileus The hope of re operation with the combined use of agencies to prevent adhesion formation would not appear to be very promising in such instances



Fig 115—Pneumoperitoneum after enterolysis to prevent adhesion formation between anterior abdominal wall and the intestines The patient's buttocks are kept elevated for several days on pillows as shown

In a group of this type who presented definite evidence of obstruction the writer, a number of years ago, performed enterolysis of the entire small intestine after initial decompression by suction Universal adhesions are the rule in such instances Before closure of the abdomen about 1000 to 1500 cubic centimeters of air was run in with the aid of sterilized bottles and tubing used for purposes of introducing pneumothorax During the convalescent period these patients' buttocks were kept elevated on two or three pillows with the thought in mind that the air would accumulate largely between the intestinal loops and the anterior abdominal wall (Fig 115) This maneuver it was believed, would obviate adhesion formation between the intestines and the anterior abdominal wall The first patient upon whom this procedure was carried out had been operated upon thirty times for intestinal obstruction The patient had once been a student nurse in training The writer did her thirty first operation It was learned subsequently that she was a morphinist No subsequent operations for obstruction have been necessary, but the patient has been admitted to hospital for brief stays of a few days on several occasions when she complained of gas pains *Intestinal* colic has not been definitely present on any of these occasions and gaseous distension of the small intestine has been absent Yet, immediate relief has been afforded by the application of suction to an inlying duodenal tube On one of these entries, an attempt at carbon dioxide inflation of the peritoneum was made to see whether a free peritoneal cavity was present Multiple adhesions were again present After the lapse of more than ten years, she declared herself well and free from morphinism, if her statement is to be credited

No such air inflations have been done in recent years after enterolysis in the unobstructed phase The writer has come to feel that, partial enterectomy, in suitable cases, with sacrifice of that segment of gut involved in the adhesions is the better procedure A number of patients have been treated successfully in this manner

The writer has come to know either through correspondence or in consultation with surgeons throughout the country, of a number of patients who have had multiple operations for adhesions Dr Hans E Schiffbauer at the Los Angeles County Hospital in California showed the writer two such patients, who were habitues of the hospital Both were nurses and both were morphinists Both patients had had a large number of operations Suction applied to an indwelling duodenal tube has come to be a great boon to such patients, in avoiding the necessity for further operation

In patients observed in more recent years, who have had multiple operations for adhesions, causing obstruction, the writer has observed some who have been operated upon principally because of vomiting, in whom the obstructive symptoms of *intestinal colic* had not been prominent Several of these patients have exhibited histamine achlorhydria and have had a low basal metabolic rate Improvement has attended the administration of desiccated thyroid, and the vitamin B complex

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Chapter XVIII

INTESTINAL OBSTRUCTION DUE TO EXTERNAL HERNIA

A PATHOGENESIS

The hernial orifices through which contents of the abdomen may protrude have for the most part hard fibrous edges which quickly compress and strangulate an intestinal loop which makes its way through such a channel The external orifices at which hernia occurs *most frequently are*, the inguinal, femoral, and umbilical, these are also the hernias that most commonly give rise to intestinal obstruction and symptoms of strangulation Less frequently strangulation may be seen in incisional, epigastric, semilunar, obturator, perivesical, lumbar, sciatic, and perineal hernias Out of 2032 operations for hernia at the Ho pital for Ruptured and Crippled, Bull and Coley reported 24 cases of strangulation The following table gives the distribution of cases of strangulated hernia as noted by their authors

TABLE XXXVII —INCIDENCE OF THE VARIOUS TYPES OF HERNIAS IN STRANGULATION

Author	Date	Total number *of cases*	Inguinal	Femoral	Umbilical	Others
Thorburn	1903	110	55	37	17	1
Erdmann	1904	58	31	19	6	2
Hilton	1907	529	250	250	—	29
Alexander	1913	105	60	25	20	—
Deaver and Ross	1915	156	77	50	21	8

The *relative* frequency of the different types of hernia and the incidence of strangulation is noted in the following table Whereas, inguinal hernia is more common, it is apparent that strangulation is relatively more frequent in femoral and umbilical hernias

TABLE XXXVIII – THE INCIDENCE OF HERNIA AND STRANGULATION

	Date	Total no of cases	Inguinal			Femoral			Umbilical			Incisional		
			No of cases	Per cent	Strangulated Per cent	No of cases	Per cent	Strangulated Per cent	No of cases	Per cent	Strangulated Per cent	No of cases	Per cent	Strangulated Per cent
Beller and Colp	1925	4 139	3 208	77	4 0	294	7 0	3	167	4 0	15 0	377	9 0	3 0
Erdmann	1927	2 587	2 300	89	1 8	97	3 7	²5	29	1 1	17 2	145	5 6	5 5

Strangulated hernia is a disease of active adult life, most of the cases occurring between the ages of 20 and 50, although it may obtain from infancy up through old age

Considerable study has been devoted to the mechanism by which incarceration and strangulation occur Gatch and his associates have recently studied the mechanism by which intestinal loops become incarcerated and give rise to strangulation In studying the behavior of gas when trapped under pressure in the bowel, these authors found that a loop

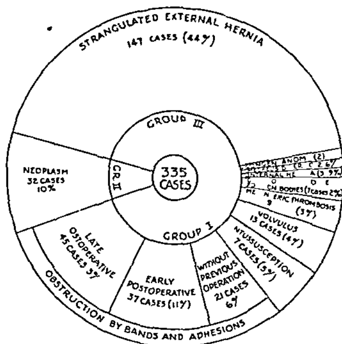


FIG 116—The incidence of various types of intestinal obstruction over a ten year period at the Massachusetts General Hospital during which time there were 39,936 surgical admissions 335 cases of bowel obstruction were seen The high incidence of strangulated hernia in this series is striking (McIver Arch Surg 25 1101 1939)

of intestine may slip with ease into a pocket from which there is no escape, but into which additional loops may be aspirated an adhesive band or an abnormal fold of the peritoneum may also isolate a loop of intestine in this manner Under the influence of active intestinal peristalsis gas is driven into the pocket, but due to the valve-like action of the more proximal compression, the gas does not escape The process is repeated and gas now under increased pressure causes the loop to distend exerting traction, which aspirates more intestine into the pocket and, incident to the intestinal strangulation considerable gas and fluid accumulate within the loop itself

There is no law that determines the exact seat of constriction in hernias, usually however, one of the tendinous apertures through which the hernia

protrudes cramps the content of the sac In inguinal hernia, the external ring constitutes the more frequent cause of strangulation Strangulation at the internal ring occurs fairly commonly, and less frequently a constriction in the sac may constitute the strangulating mechanism Right inguinal hernia is more common than left, and similarly, strangulation on the right side is observed more frequently than on the left Because of the more gradual development of direct inguinal hernia and the progressive stretching of the hernial orifice, strangulation only infrequently occurs Femoral hernia ranks as one of the commonest causes of intestinal strangulations (Souttar) When it is remembered that femoral hernia is much less common than inguinal and that the number of cases of strangulation of femoral hernia closely approximates that of the inguinal group, the likelihood of strangulation in femoral hernia is quite apparent The rigid walls constituted by Poupart's, Gimbernat's, and Cooper s ligaments form a very treacherous aperture when a loop of bowel protrudes itself into it In consonance with the greater incidence of femoral hernia in women, strangulation also occurs more frequently in the female The rigid fascial insertions into the linea alba at the umbilicus make for frequent strangulation of the intestine at this site Not infrequently, however, the omentum precedes entry of the intestine into this orifice by a considerable period of time, and the walls are gradually stretched out so that later, when the intestine (usually the transverse colon) finds its way into this umbilical sac, *the walls are somewhat more yielding than previously*

B PATHOLOGY

The effect on the intestine consequent upon being engaged and strangulated in a hernial orifice is much as that observed experimentally when a loop of intestine and its mesentery are tied off In consequence of interference with the venous return, rapid congestion, edema, and swelling occur Transudation of fluid into the lumen of the bowel as well as into the hernial sac follows The fluid in the sac early is clear and sterile Incident to gaseous distension and fluid accumulation within the loop, progressive changes in the bowel wall ensue as manifested by ulceration of *the mucosa livid appearance of the bowel which progressively deepens* until perforation and gangrene follow unless the constriction is released When the bowel is no longer viable, the fluid in the hernial sac may be bloody or turbid and bacteria can be demonstrated on culture of the fluid Bacteria may occasionally be demonstrated in the fluid of the hernial sac when the bowel is viable

In large umbilical, scrotal, and incisional hernias incarceration or obstruction of the loop of intestine in the sac rather than strangulating effects are observed Under conditions in which fluid accumulates and gas becomes trapped in the incarcerated intestinal coils the pathological changes of strangulation may also be seen

C CLINICAL FEATURES

The symptoms of strangulated hernia are those of intestinal obstruction with the addition of a painful tender and often tense swelling at one

of the hernial orifices When sudden engagement of an intestinal loop by a hernial ring occurs, the pain may be so severe that temporary collapse may follow The history of patients having been aware of the existence of a hernia is usually obtained, occasionally, however, strangulation may be the first warning of the presence of such a protrusion

It is first important to determine that a patient actually has a hernia by the criteria one ordinarily employs to demonstrate its presence In the inguinal region inflammation of the inguinal or iliac lymph nodes must be excluded, in the male, torsion of a normal or inguinal testis should be ruled out Thrombosis or phlebitis of the veins of the spermatic cord may cause difficulty in diagnosis In femoral hernia, thrombosis of the femoral or upper portion of the saphenous vein may give rise to confusion Strangulated umbilical and femoral hernias may simulate local subcutaneous circumscribed infections with intense reddening of the skin over the sac, owing to liquefaction of infarcted fat

The symptoms of obstruction viz, severe colicky pain, nausea, and vomiting help to establish the diagnosis The content of the sac can frequently be determined by percussion, a tympanitic note being given by imprisoned bowel In the presence of considerable exudation into the sac, this note may be dampened somewhat but is never as dull as the percussion note produced by incarcerated omentum The presence of gut in the sac can frequently be demonstrated by a lateral x ray film (Fig 117) A strangulated hernia presents usually considerable tenderness and an impulse on cough can not be elicited In obstruction or incarcerated hernias, an impulse is present on cough and tenderness is absent or slight

In patients presenting the symptoms of early obstruction but no evidence of hernia other than tenderness at one of the hernial orifices strangulation of an enterocele (Richter's hernia) must always be given consideration In this condition a portion of the bowel wall is constricted in a hernial orifice the lumen of the intestinal canal remaining unobstructed This portion of the bowel may become gangrenous and a fistula may form giving rise to the development of an abscess at the site of presentation Impingement of a portion of the bowel wall is most likely to occur in small hernial orifices with tendinous margins The inguinal femoral linea alba (epigastric) and obturator apertures are the common sites for its occurrence Strangulation of Meckel s diverticulum in a hernial sac is known as Littre s hernia Sweet has recently collected 14 such cases from the literature In strangulation of the interparietal variety of indirect inguinal hernia described by Kronlein the swelling and tenderness may be confined to unusual areas paralleling the direction and plane in which the hernia has dissected up over the abdominal wall

Epigastric hernias usually present properitoneal fat as their only content Occasionally however the parietal peritoneum is evaginated sufficiently into the aperture in the linea alba to permit engagement of the intestine In 1914 Moschcowitz stated that 14 instances of strangulated epigastric hernia had been reported and in only 5 of these was there intestine in the sac Transverse colon is the usual occupant of the sac but

small intestine may also find its way into the pouch Large epigastric hernias are usually para-umbilical in location

Pain down the inner side of the thigh as far as the knee (Howship-Romberg sign), corresponding to the sensory distribution of the obturator nerve in a patient with symptoms of intestinal obstruction, is suggestive of the presence of strangulation of an obturator hernia It is only infrequently diagnosed prior to laparotomy Vaginal or rectal examination may disclose a tender mass above the inferior ramus of the ischium Watson (1938), in his monograph on hernia states that 420 cases of obturator hernia are reported Strangulation is common and the mortality is high The Howship Romberg phenomenon was noted in 68 cases Of 396 cases of obturator hernia collected by Watson, a large number were strangulated



Fig 117—The presence of bowel in a strangulated femoral hernia detected by x ray examination The arrows indicate the ectopic position of the bowel Only rarely does a roentgenogram add useful information to the diagnosis of strangulated external hernia

Fromme (1908) claims to have made the diagnosis of a supravesical hernia by noting bulging of the anterior *bladder wall through the* cystocope Warvi and Orr (1940) state that approximately 60 cases of hernia about the urinary bladder are reported in the literature Of these, 37 are true supravesical hernias Strangulation is not uncommon In the cases tabulated by Warvi and Orr, the mortality was 44 1 per cent

Lumbar hernias are occasionally strangulated Of 115 cases collected by Watson, 13 presented evidence of strangulation

Strangulation may be the first sign of a sciatic hernia Watson says that only 30 cases of sciatic hernia have been reported Pain may be referred down the posterior side of the thigh and tenderness may be demonstrated at the gluteal fold which may in part be obliterated

Perineal hernias only infrequently give rise to intestinal obstruction of an acute nature (*Black*)

D TREATMENT

Perhaps nowhere is better illustrated the success of early treatment of intestinal obstruction than in strangulated hernia Bower found that the average length of time elapsing between onset of the symptoms and operation for strangulated hernia was 31 hours, whereas, for cases of intestinal obstruction, the same time was 76 6 hours The latter being greater by 177 per cent Braun and Wortmann state that 1796 cases of strangulated hernia were *seen at the* Friedrichshain Hospital in Berlin between the years 1903-

1922, in this group there was a mortality of 280 cases, or 15 6 per cent In 1509 cases of the entire group no gangrene was present, of these, 136 died a mortality of 9 0 per cent Of 286 cases of gangrene, 144 died, a mortality of 50 9 per cent Frankau has recently reported the results of a collective investigation instigated by the Association of Surgeons of Great Britain and Ireland on strangulated hernia There were 1487 cases in the group, the mortality was 15 7 per cent In 105 instances, because of gangrene of the bowel, resection was done with 45 deaths a mortality of 42 8 per cent

The greater ease in arriving at the diagnosis of intestinal obstruction in an external hernia which pre ents the features of intestinal obstruction naturally accounts for the fact that these patients come to operation sooner than do patients with internal types of intestinal obstruction The fact that definite local physical findings are present helps very much in determining the presence of bowel occlusion early The treatment indicated for all strangulated hernias is immediate operation under appropriate anesthesia and deliberate cutting of the band that causes the strangulation Blood loss, if reflected in the systolic pressure should be replaced by pre operative transfusion The incision should generally be a little more generous than the usual hernia incision to permit of adequate exposure A strangulated femoral hernia should be exposed through the inguinal approach above Poupart's ligament The hernial sac should then be opened and the condition of the bowel ascertained A turbid or bloody fluid in the sac gives evidence of prolonged vascular impairment A return of the normal luster of the bowel and pulsation in the vessels is adequate evidence for returning the loop to the abdomen In instances where the bowel wall presents a ring like area of constriction on one or both limbs of the herniated intestine at the site of strangulation the placement of a few inverting sutures—Summers' stitch of fine silk placed after the Halsted mattress pattern will not only help to avoid immediate trouble from leakage but will also serve to avoid subsequent stricture formation Fig 114 p 351 In instances in which the viability is doubtful the writer favors primary intestinal re ection over exteriorization Primary resection has come to replace exteriorization in dealing with devitalized bowel in this clinic in all types of strangulating obstruction When the patient is extremely ill simple exteriorization and drainage of the oral loop is the alternative procedure of choice Whenever possible in such instances it is best to exteriorize through a simple vertical incision—a maneuver which permits of dealing more adequately with the hernia When the physical status of the patient does not warrant this refinement howe er it is to be omitted The hernia itself is to be dealt with by standard techniques The use of interrupted sutures of silk is an important item in enhancing the chances of permanent cure of the hernia

The reduction of strangulated hernias by taxis is a method of doubtful value Unless the patient is seen within a short time of the strangulation taxis is better not attempted A strangulated non viable bowel has occasionally been reduced when both physician and patient had been of the opinion that the danger was past Mere reduction of the strangulated hernia by spinal anesthesia is to be condemned unless operation is imme-

diately performed In his comprehensive report on the value of spinal anesthesia in ileus, Duval refers to several cases where perforations were found in the bowel after reduction Casten (1941) has reviewed the literature of reduction *en masse* of strangulated hernia He states that 207 cases are to be found reported in surgical literature Even though it is strongly felt that omentum is the sole content of the sac, this should be no deterrent to immediate operation

In operating upon strangulated hernias it is well to bear in mind the possibility of retrograde incarceration This hernia is frequently described as hernia "en W" (deBeule) A portion of the loop that becomes engaged in a hernial sac may subsequently escape and return into the peritoneal cavity while the remainder of the intestine and the mesentery of the entire segment initially present in the hernial sac continue to be compressed by the strangulating mechanism The loop that remains inside the peritoneal cavity may be often more severely devascularized than the loop within the sac

Obturator, supravesical and sciatic hernias causing intestinal obstruction are best recognized and reduced though a laparotomy incision

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CHAPTER XIX

INTESTINAL OBSTRUCTION DUE TO INTERNAL HERNIA

INTERNAL hernia is relatively infrequent, at the Friedrichshain Hospital in Berlin during an 18 year period, 1795 cases of external hernia came to operation Only 21 cases of internal hernia presenting features of obstruction were treated during the same interval of time Among 400 cases of intestinal obstruction reported by Guillaume, only four concern internal hernia Of 456 cases of intestinal obstruction reported by Küttner from Breslau, however, 23 were instances of internal hernia

The sites at which these strangulations may occur are (1) diaphragmatic hernia, (2) hernias of the foramen of Winslow, (3) hernias of the paraduodenal fossae, (4) persistent hole in the mesentery, (5) hernia into the intersigmoid fossa, and (6) pericecal hernias

A DIAPHRAGMATIC HERNIA

Pathogenesis

In 1925, Hedblom collected 378 cases of diaphragmatic hernia of which 126 or 33 3 per cent were strangulated or exhibited symptoms of acute intestinal obstruction Patients with intestinal obstruction due to this agency may present themselves at any time of life Many are congenital, but those necessitating operation for intestinal obstruction are largely the result of trauma The hernias of congenital origin are to be enumerated as hernia through an abnormal aperture in the diaphragm or hernia through one of the normal foramina of the adult diaphragm Of these, para esophageal hernia is the most common and usually manifests itself *later in life and is frequently present under circumstances that increase* intra abdominal pressure (Rigler and Eneboe) Hernias of this sort are rarely strangulated though volvulus of the stomach may occur in such a hernia The strangulated diaphragmatic hernia of the infant is observed most frequently through the pleuroperitoneal hiatus, an opening which usually is closed by the third month of fetal life The anterior, lateral and central portions of the diaphragm are formed from the transverse septum and fused ventral mesentery The remaining postero-lateral portion is formed by the fusion of the dorsal mesentery and the mesoderm derived from the receding Wolffian body and the pleuroperitoneal membrane which comes from the pulmonary ridge Failure of fusion of these elements at any *of their normal points of union* may cause a communication to persist at the fetal pleuroperitoneal hiatus

Crushing injuries of the chest and upper abdomen or stab or bullet wounds that penetrate the diaphragm are the usual cause of the develop ment of traumatic diaphragmatic hernia In children they are frequently the result of automobile accidents in which the child is run over or is struck forcibly by bumper or fender

Pathology

The colon is the portion of the bowel that most frequently herniates into the chest and becomes obstructed by the compression of the muscular diaphragm Any abdominal viscus, however, may be herniated into the chest and any portion of the intestine may be obstructed Unlike strangulated external hernias in which the compression ring is unyielding and in which gangrenous changes in the bowel occur with frequency, in diaphragmatic hernia these are unusual The strangulating mechanism being a



Fig 118—Diaphragmatic hernia with symptoms of acute intestinal obstruction (Pleuro-peritoneal hiatus hernia) (a) Antero-posterior film showing large gastric loculus in the thorax The patient was cyanotic and dyspnoeic prior to employment of suction (b) Lateral film made at the same time (c) After surgical repair of the defect. The patient Mr D A aged 27 Univ Hosp No 662347 was operated upon for his second attack of bowel obstruction occasioned by this congenital defect

muscular ring and capable of being dilated, obstruction rather than strangulation of the bowel occurs initially though devascularization of the herniated bowel may follow unless the hernia is reduced

Clinical Features

The symptoms of obstruction may occur within a very short time after the receipt of the injury, but ordinarily some time elapses before attention is directed to the serious character of the lesion Congenital pleuro peritoneal hiatus hernias have been observed in this clinic in which no suggestion of the presence of the defect became evident until the patient became obstructed in early adulthood Dyspnoea is not an infrequent complaint due to the compression of the lung by increase in the thoracic contents and may antedate considerably the symptoms of obstruction Cyanosis has been present in most of the obstructed pleuro peritoneal hiatus hernias and traumatic ruptures of the diaphragm observed in this clinic Severe pain is complained of there is usually nausea and vomiting and tenderness in the upper left abdomen Intestinal obstruction due to hernia occurs almost invariably through the left diaphragm Hernia through the dome of the right diaphragm does occur but it is usually the

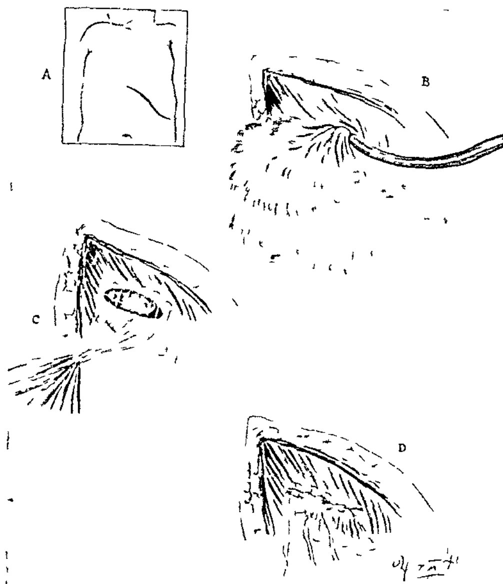


FIG 119—Repair of pleuro peritoneal hiatus hernia in diaphragm (a) The incision (b) The maneuver of the late C H Mayo for equalization of pressures in pleural and peritoneal cavities Injection of air through the catheter into the pleural space causes the intestine to return spontaneously frequently if the abdominal viscera are not adherent in the thorax (c) Placement of interrupted Halsted sutures of silk (about 5 pound test) to close the defect (d) Plan of Weinberg employing loose perineal fascia to suture over site of closure in instances in which the diaphragmatic closure is not completely satisfactory If the approximation of the sutures shown in (c) is under tension the phrenic nerve should be pinched with a hemostat along the left border of the heart to avoid tension and motion during the healing period

liver which enters the pleural cavity in such instances Among 34 specimens of diaphragmatic hernia in London museums Keith found twice that hernia had occurred through the dome of the right diaphragm The

defect in each instance was occupied by liver In his series there were 17 hernias through the left pleuroperitoneal hiatus but only 4 through the right On examination, a diminished excursion of the thorax on the left side accompanied by impairment of resonance over the chest can usually be made out Litten s phenomenon is usually absent on the left Anteriorly, there may be tympany when considerable gas is present in the bowel and, posteriorly there is ordinarily dullness due to the compression of the lungs Frequently intestinal borborygmi and intestinal gurgling sounds may be heard over the chest Gibson calls attention to the diagnostic significance of cardiac displacement occasioned by the shift in the position of the mediastinum An x ray film of the abdomen and chest will show the presence of gas above the diaphragm (Fig 118) A barium enema may likewise demonstrate the presence of the colon above the level of the diaphragm

In infants with congenital deficiency of a portion of the diaphragm attacks of cyanosis and dyspnoea, followed by vomiting usually direct attention to the existing state of affairs Hernia through the esophageal hiatus is not to be confused with a congenitally short esophagus in which the stomach may be in the thorax (Bailey)

Treatment

In intestinal obstruction due to diaphragmatic hernia of traumatic origin, ordinarily no direct attack should be made on the intestine incarcerated in the thoracic cavity until the obstructive element has been dealt with The present high mortality of 67 deaths (53 1 per cent) among 126 cases of intestinal obstruction occurring in the 378 cases reported by Hedblom is indicative not only of the danger of incarceration of the intestine in the thoracic cavity but also of the fact that too much surgery has been undertaken The strangulating mechanism being less rigid in diaphragmatic hernias than in most external hernias devascularization of the imprisoned loops does not occur as readily In six cases of bowel obstruction due to diaphragmatic hernia in children Truesdale performed primary cecostomies and only secondarily reduced the hernia and repaired the defect in the diaphragm there were no deaths in this series The release of the intestines and closure of the rent in the diaphragm is to be performed through the abdomen though occasionally when the intestine is adherent to structures within the thoracic cage as not infrequently happens a thoracotomy will also have to be made to free the bowel and other structures from their abnormal attachments A preliminary x ray film will serve to indicate which portion of the bowel is obstructed Distended small intestine may be decompressed by suction applied to an inlying duodenal tube if the colon is obstructed cecostomy or colostomy is indicated A preliminary section of the phrenic nerve as advised by Harrington will frequently diminish the tension of the muscle pull of the diaphragm upon the gut and improve the patient s status In the experience of the writer the inlying duodenal tube accompanied by positioning of the patient to help empty the fundus of the stomach which lies frequently in the thorax helps more than any other single item in getting rid

of cyanosis and dyspnoea It is important to take check up films, before operation, to see that the distended stomach has been decompressed satisfactorily

In the congenital hernias, the most common defect is absence of the posterior one fourth of the diaphragm In the one experience which the writer has had with the repair of this condition in the new born, the peritoneal cavity appeared to be too small to hold the bowel after closure of the diaphragmatic defect The sutures in the peritoneum and fascia for closure of the vertical left rectus incision had to be removed in order to permit of replacement of the gut in the peritoneal cavity, interrupted sutures of linen placed in the skin alone being depended upon The infant stood the procedure well, but died from a puncture pneumothorax of the lung several days later At necropsy the left kidney was still in the thorax Orr and Neff, in recording a successful case, state that 16 infants under one year of age have been submitted to operation for the repair of a diaphragmatic hernia The mortality was 47 per cent

Repair of a diaphragmatic hernia may be undertaken either through an abdominal or a thoracic incision, or through either with a separate complemental incision into the other cavity, or through continuation of an incision in either cavity into the other In the main, the abdominal incision has the wider range of usefulness The writer, has employed the long left subcostal incision in the repair of diaphragmatic hernia—the same incision which has proved so useful in gaining access to the fundus of the stomach in extensive or total gastric excision The maneuver of Mayo, to inject air into the pleural cavity, to facilitate intraperitoneal replacement of the abdominal viscera, herniated into the thorax, is an excellent procedure (Fig 119) If the peritoneal viscera are not adherent to the lung, thoracic wall or pericardium, employment of the Mayo maneuver or slitting the diaphragm will permit ready reduction In traumatic hernias of long standing, in which intimate adherence of thoracic and peritoneal viscera is present, employment of the complemental thoracic opening may be necessary to effect complete and safe reduction of the hernia

Weinberg (1937) has suggested employment of the loose mobile perirenal fascia in the closure of large diaphragmatic defects—a suggestion which this writer has found to be useful The small pleuro peritoneal hiatus hernias may be closed satisfactorily with Halsted mattress sutures of silk When feasible, imbrication by overlapping insures a completely satisfactory result Silk is to be preferred to catgut for the closure

B INTESTINAL OBSTRUCTION DUE TO HERNIA INTO THE FORAMEN OF WINSLOW

Pathogenesis

Ullman in 1924, and Dewis and Miller in 1927 made comprehensive reports on this subject Dewis and Miller found 34 cases reported in the literature up to that time

The entire mobile small intestine and a large portion of the colon may find its way through the foramen of Winslow into the lesser peritoneal sac The condition may occur at any age, the youngest having been 5

years and the oldest aged 77 The greater number of patients have been reported in the male sex An abnormally mobile mesentery appears to predispose to the condition The small intestine most frequently herniates into the foramen and, in less than one third of the cases, portions of the large intestine and usually the appendix, ascending and transverse colon have been found to be contents of the sac

Pathology

A large segment of the bowel may become imprisoned in the lesser omental bursa or only a short loop One instance is reported in which a diverticulum of the intestine was the only content of the sac and in two instances a portion of the jejunum was the only segment of gut strangu lated In a few instances the sac has ruptured and the intestine has herniated into the transverse mesocolon or through the gastrohepatic omentum Bowel has entered the lesser omental bursa through an open ing in the gastro colic omentum An associated intussusception from the ascending into the transverse colon has been found co incident with hernia of the intestine through the foramen of Winslow Langley reports an instance in which two types of internal hernia were present one was peri cecal, the other through the foramen of Winslow The short jejunal loop in the foramen was non viable and the patient died The bowel within the lesser sac usually dilates moderately rapidly and has been found perforated A number of cases of strangulation in this type of hernia occur constriction of the bowel is occasioned by the structures bounding the aperture In front in the gastro hepatic omentum are the common bile duct, portal vein, and hepatic artery behind the inferior vena cava and the spinal column

Clinical Features

The condition has never been diagnosed pre operatively and has occasionally not even been recognized at operation The symptoms of intestinal obstruction apparently develop moderately slowly At any rate, Green who has studied this point in particular, finds that in a large num ber of cases considerable time has elapsed between the onset of the symp toms and the appearance of the findings demanding operation In several cases the pain has been moderately severe, there has been little or no vomiting—an observation attributed largely to the fact that after the con tent of the stomach and duodenum is evacuated compression of the small intestine precludes the return of more intestinal content by vomiting When the infarcted segment is long, the blood loss may be great

Treatment

The important feature in the management of these cases is early recog nition that a serious lesion exists and early resort to operation The absence of a good deal of intestine from the free peritoneal space and the presence of a cyst-like mass in the upper right abdomen at operation should establish the diagnosis In some instances reduction by simple traction on the herniated bowel suffices to return the intestine to the free

of cyanosis and dyspnoea It is important to take check up films, *before operation, to see that the distended stomach has been decompressed satisfactorily*

In the congenital hernias, the most common defect is absence of the posterior one-fourth of the diaphragm In the one experience which the writer has had with the repair of this condition in the new born, the peritoneal cavity appeared to be too small to hold the bowel after closure of the diaphragmatic defect The sutures in the peritoneum and fascia for closure of the vertical left rectus incision had to be removed in order to permit of replacement of the gut in the peritoneal cavity, interrupted sutures of linen placed in the skin alone being depended upon The infant stood the procedure well, but died from a puncture pneumothorax of the lung several days later At necropsy the left kidney was still in the thorax Orr and Neff, in recording a successful case, state that 16 infants under one year of age have been submitted to operation for the repair of a diaphragmatic hernia The mortality was 47 per cent

Repair of a diaphragmatic hernia may be undertaken either through an abdominal or a thoracic incision, or through either with a separate complemental incision into the other cavity, or through continuation of an incision in either cavity into the other In the main, the abdominal incision has the wider range of usefulness The writer, has employed the long left subcostal incision in the repair of diaphragmatic hernia—the same incision which has proved so useful in gaining access to the fundus of the *stomach in extensive or total gastric excision The maneuver of Mayo,* to inject air into the pleural cavity, to facilitate intraperitoneal replacement of the abdominal viscera, herniated into the thorax, is an excellent procedure (*Fig 119) If the peritoneal viscera* are not adherent to the lung, thoracic wall or pericardium, employment of the Mayo maneuver or slitting the diaphragm will permit ready reduction In traumatic hernias of long standing in which intimate adherence of thoracic and peritoneal viscera is present, employment of the complemental thoracic opening may be necessary to effect complete and safe reduction of the hernia

Weinberg (1937) has suggested employment of the loose mobile perirenal fascia in the closure of large diaphragmatic defects—a suggestion which this writer has found to be useful The small pleuro peritoneal hiatus hernias may be closed satisfactorily with Halsted mattress sutures of silk When feasible, imbrication by overlapping insures a completely *satisfactory result Silk is to be preferred to catgut for the closure*

B INTESTINAL OBSTRUCTION DUE TO HERNIA INTO THE FORAMEN OF WINSLOW

Pathogenesis

Ullman in 1924, and Dewis and Miller in 1927 made comprehensive reports on this subject *Dewis and Miller found 34 cases reported* in the literature up to that time

The entire mobile small intestine and a large portion of the colon may find its way through the foramen of Winslow *into the lesser peritoneal* sac The condition may occur at any age, the youngest having been 5

states that 40 verified instances of right paraduodenal hernia have been recorded Together, therefore there must now be upwards of 150 cases of so called paraduodenal or mesentericoparietal hernias on record

In the left paraduodenal hernia the inferior mesenteric vein runs in the free margin of the anterior covering of the sac and when operation is done for its relief this point must be remembered The lower portion of

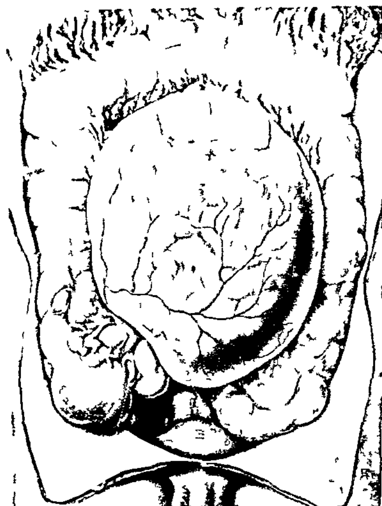


Fig 120—Left paraduodenal hernia (Desjardins Ann Surg 67 195 1918)

the ileum is usually the first to become engaged in the sac the extraction of the more proximal loops should facilitate the reduction as Bramlett and Ashhurst have pointed out The pocket points to the left and has its orifice at its right free margin The fossa is usually known by the name of Landzert It has on its right the root of the mesentery and posteriorly the peritoneum covering the psoas muscle renal vessels the ureter and a portion of the left kidney

peritoneal space In others, primary deflation of the obstructed intestine, preferably performed through an opening in the gastrohepatic omentum, should be done Occasionally gentle stretching of the edges of the epiploic foramen will serve to permit reduction of the herniated content Jeanbreau and Riche describe a debridement of the foramen, an operation that they have developed on the cadaver to facilitate reduction of the intestine into the greater peritoneal sac Through a short transverse incision in the gastrohepatic omentum just above the duodenum, the index finger of the left hand is insinuated through the omentum and the hepatic artery and portal vein pulled to the left The right index finger then gently pulls the common duct to the right and gradually the foramen may be enlarged because of the laxity of the retroduodenal tissues If the bowel is non viable, it may be amputated and removed from the left side of the gastrohepatic omentum

It is an interesting fact that in cases of recovery following reduction of strangulated hernia through the epiploic foramen, the time elapsed between the onset of symptoms and operation was nine days, in the series that died, the interval was only five days It is therefore apparent that the degree of strangulation is the best index of the prognosis About a dozen operative recoveries have been reported Engstad stresses the importance of enterostomy as the most significant feature of a well planned operation in the ill patient Recent successful reductions of bowel strangulated in the foramen of Winslow have been reported by Aigrot, Gabrielli and Mitchell

C PARADUODENAL HERNIA

(Mesentericoparietal or retromesocolic hernia)

Pathogenesis

In his classical monograph on retroperitoneal hernia, Moynihan described nine different fossae in the neighborhood of the duodenum Two of these occasionally captivate the intestine behind the mesentery and give rise to intestinal obstruction Objection has been raised to the belief that the bowel finds its way into these preformed pockets Andrews in a forceful paper insists that the term retroperitoneal hernia is a misnomer and believes that the small bowel is imprisoned behind the mesentery of the developing colon Longacre, Haymond and Dragstedt, and a number of continental observers (quoted by Longacre) support this thesis The condition is also said to have been present in the new-born, an item which speaks strongly against the pushing force of the bowel in enlarging the peritoneal pocket

Pathology

These hernias may be divided into two fairly strict divisions—left and right duodenal hernia In 1917 Desjardins stated that 85 cases of left paraduodenal hernia had been reported In 1924, Nagel said that 100 such cases were on record Occasionally these hernias are strangulated but a chronic type of obstruction appears to be more frequent These patients frequently have an indefinite type of complaint for which they are treated by conservative measures over a number of years Exner

1 In right paraduodenal hernia, the opening of the sac is on the left and the opening faces to the left
2 In left paraduodenal hernia, the opening of the sac is on the right and the opening faces to the right (see Fig 120)
3 The superior mesenteric artery runs in the anterior free margin of the sac in right paraduodenal hernia
4 The inferior mesenteric vein runs in the free margin of the anterior wall of the sac in left paraduodenal hernia

Treatment

The potential for obstruction is always present and when the condition is discovered accidentally, the sac should always be laid open and dealt with in such a manner that recurrence of incarceration will not be likely The surgeon must always be mindful of the position of the blood vessels in the anterior margin of the sac In speaking of right paraduodenal hernia, Exner states the history of the condition may be divided into three distinct periods "1861 1903 when 19 cases were described, but only 4 operations were performed and only one patient recovered, 1904-1923, when 10 ca es were reported with 8 operations but still with only one recovery, 1923 1932, when 10 cases were reported and all were operated upon with 8 recoveries" The writer found most of the small intestine in a left paraduodenal hernial pocket recently at operation for duodenal ulcer Repair of the hernia and gastric resection were carried out successfully at the same sitting On a number of occasions a mall paraduodenal hernial pocket has been found and clo ed at operation, incident to ab dominal exploration

D CONGENITAL HOLE IN THE MESENTERY

Hernia through a congenital aperture in the mesentery has as its favorite site, for strangulation of the intestine by this mechanism a per sistent defect in the terminal mesentery of the ileum Herniation of the intestine through a defect in either broad ligament has also been reported from time to time Defects have been noted in the transverse mesocolon as well as in the gastrocolic omentum Cutler has placed on record a case with recovery following intestinal resection after herniation of a portion of the intestine through an aperture in the mesentery He refers to 28 other cases reported in the literature Sohn related that about 53 cases of internal hernia through mesenteric defects were on record Gatewood states that the disorder has not been identified prior to operation In 1932 Edwards reviewed 20 cases, the mortality was 28 5 per cent Martzloff found 15 recorded ca es of prolapse of the bowel through a preformed opening in the greater omentum and added one more Gentile observed another in 1933 Hunt and Masson and Atkinson have recently reviewed the instances of herniation through openings in the broad ligaments of the uterus Fifteen such cases are to be found in the literature Tears in the broad ligament after the Baldy Webster type of uterine suspension predispose to its occurrence Loops of intestine may also become encircled

Right duodenal hernia is less frequent, Nagel having been able to find only 29 cases at the time of his report, 13 gave symptoms of acute intestinal obstruction 6 had a history of previous similar attacks, 10 of the obstructed cases were operated upon, 8 of whom died with only two recoveries The fossa of Waldeyer is the name of the pouch into which the intestine herniates itself Nagel also states that hernia of this type may occasionally occur in the inferior duodenal fossa The hernial sac of right paraduodenal hernia lies behind the ascending and transverse mesocolon The small intestine is largely contained within this sac, whose orifice is situated behind and to the left of the sac on the lumbar vertebrae The superior mesenteric artery or its continuation, the ileocolic lies in the anterior margin of the sac

Clinical Features

Incarceration rather than acute strangulation characterize most of the obstructed cases Stasis in the sac is usual even in those patients who have few symptoms, an occurrence which aids in their recognition The rounded, sharply circumscribed lower border of the barium mass in the bowel lends the impression that the small intestine is contained in a bag and serves to establish the diagnosis (Fig 121) A number of cases have been recognized by these findings alone (Kummer, Case and Upson, Taylor, Exner) It is problematic however, in an acutely obstructed case in which the oral administration of barium would be inadvisable, whether the gaseous distension of the imprisoned intestinal coils would give the same appearance In unobstructed cases where the oral administration of barium is permissible roentgenologists have been able to decide whether the paraduodenal hernia present was of the right or left variety on the basis of (1) the relationship of the stomach and (2) the colon to the incarcerated mass of small bowel and (3) whether the terminal ileum lies outside the hernial sac (Exner) Non rotation of the small bowel is to be differentiated from paraduodenal hernia in that, there is no bag like arrangement of the intestinal coils and at operation, no sac is present Peritoneal tuberculosis occasionally attends paraduodenal hernia—probably a result of the stasis The writer observed this complication in a case of left paraduodenal hernia At operation the surgeon may find the following criteria useful in the differentiation of right and left paraduodenal hernia (Averbach 1937)



FIG 121 —Right paraduodenal hernia The coils of small intestine appear as though restrained in a bag

preoperatively Reid has recently recorded another instance A 5 inch loop of jejunum 4 feet from the duodenojejunal angle had found its way into the intersigmoid fossa The patient died In addition to the successful case of Murphy, there are also operative recoveries reported after extraction and reduction of the incarcerated loop of small intestine by Krall and Erkes

F PERICECAL HERNIA

Three fossae may be recognized near the junction of ileum and cecum (1) ileocolic, (2) ileocecal (ileo appendicular) (3) retrocolic These anatomical pouches owe their origin to the formation of folds as related to the division of the ileocolic artery Only the two latter fossae are of surgical interest because of the possibility of arrest and strangulation of the intestine within the pocket

Moynihan found 7 authentic cases of ileocecal hernia on record Moynihan accepts as bona fide 6 cases of the retrocolic variety with intestinal strangulation of which two recovered One of these was operated upon by Körte and reported by Aschoff Van Hook reported *the successful* reduction of such a hernia in an infant 18 months old and more recently Pribram added another successful case in which 235 centimeters of small intestine were resected In 1935 Langley reviewed the literature upon the subject He states there are 26 cases of intestinal obstruction due to pericecal hernia reported Of this number 20 have been submitted to operation with 14 recoveries (30 per cent mortality), of the 6 not operated upon, all died

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about the loop that has been fixed to the abdominal wall in colostomy, unless care is taken to prevent such an occurrence by bringing the colon through the abdominal wall as far laterally as possible or by tacking the lateral parietal peritoneum to the loop employed for colostomy, in such a manner that complete encirclement is impossible

Hernia of a loop of jejunum beneath the limbs of a gastrojejunal stoma has been observed after gastrojejunostomy as well as after gastric resection (Mayo and Magoun, and Armitage) Employment of a long afferent loop is believed to favor its occurrence

The writer observed this complication once after subtotal gastric resection for duodenal ulcer The patient returned with the clinical picture of obstruction five months after the operation, the patient having been completely well in the meanwhile Because ingested barium failed to leave the stomach, a roentgen diagnosis of stomal obstruction was made On the basis of palpable intestinal loops in the upper left abdomen and intestinal colic, the condition was diagnosed clinically correctly preoperatively A loop of gut was found enormously distended The loop could not be delivered Employment of the tube suction device, shown in Fig 47b permitted complete emptying of the loop It contained 750 cc of a bilious greenish yellow fluid The gas content of the loop was not measured After the segment was emptied, it was observed to be the afferent loop to the gastrojejunal stoma which had herniated beneath the ascending and descending jejunal limbs of the stoma The obstruction had been present for a week and the posterior aspect of the loop was agglutinated so firmly to the stomach and the posterior parietal peritoenum, to preclude freeing it An enteroanastomosis by the closed method was made The patient has remained well and has continued achlorhydric despite the presence of the entero anastomosis

E INTERSIGMOID HERNIA

The persistence of the sigmoid fossa is found in a fairly large number of bodies In 100 cadavers examined by Treves such a fossa was found in 65 per cent of the cases Moynihan has found it to be present in about 70 per cent of subjects It is more constantly recognized in children and tends to become obliterated later in life It is found on the left side of the mesosigmoid near its base its orifice is round and the pouch is funnel shaped and looks downward and to the left It frequently contains the sigmoid vessels, behind which is the parietal peritoneum covering the left common iliac artery Its developmental origin is due to zygosis or physiological adhesion of the mesocolon to the posterior parietal peritoneum Hernia into this fossa is a rare event Copenhaver found no instance of its occurrence in the records of the Mayo Clinic In a report made in 1924 by Bruce and Ross, the authors state that only 10 cases of intersigmoid hernia are to be found in the literature, one of these occurred in a new born the oldest in a patient aged 66 All of these except one occurred in males A successful case is referred to by the late J B Murphy where actual strangulation of the intestine necessitating excision of the herniated loop was necessary The condition has not been correctly recognized

pre operatively Reid has recently recorded another instance A 5 inch loop of jejunum, 4 feet from the duodenojejunal angle had found its way into the intersigmoid fossa The patient died In addition to the successful case of Murphy, there are also operative recoveries reported after extraction and reduction of the incarcerated loop of small intestine by Krall and Erkes

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Chapter XX

VOLVULUS

A PATHOGENESIS

Volvulus is most commonly observed in the following portions of the intestinal canal the sigmoid flexure of the colon, the cecum, and the small intestine A long flexure in which the limbs of the loop are closely approximated, as in the sigmoid flexure, predispo es to the occurrence of volvulus (Fig 122) It is also a significant circumstance that in most instances in which volvulus of the sigmoid flexure obtains that an unusually large bowel or p eudomegacolon is often present The frequent occurrence of volvulus in Hirschsprung's disease is well known, Weeks has reported several such occurrences

The rarity with which volvulus of the transverse colon is seen bespeaks the importance in the develop ment of torsion of a narrow attachment of the mesen tery The transverse colon despite its extreme range of motion escapes frequent twisting because its points of fixation at the hepatic and splenic flexures are so far removed from one an other yet even torsion of the transverse colon has been reported (Braun and Wortmann, Melchior) Kallio has recently collected 16 cases of volvulus of the transverse colon

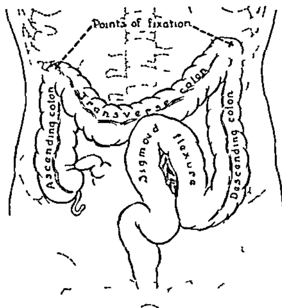


Fig 122—The potential for volvulus in the colon Sketch illustrating the ea e with which volvulus may occur in the sigmoid flexure with a narrow mesentery the lateral points of fixation of the transverse colon preclude frequent torsion of this segment of the bowel yet it does occur even here

In most statistical studies of intestinal obstruction volvulus constitutes about 10 per cent of the total number In 1000 cases of intestinal obstruction Gibson reported 121 instances of volvulus In Kuttner's Clinic at Breslau, 42 instances of volvulus were observed in 456 cases of intestinal obstruction In Russia, Serbia, Finland, and Sweden, volvulus appears far more frequently Out of 215 cases of intestinal ob-

struction reported by Perlmann from a Russian surgical clinic, 111 or more than one half were cases of volvulus Obalinski *reports amongst 110* cases of intestinal obstruction, 38 instances of volvulus of which 19 occurred in the small intestine with concomitant rotation of the cecum in four of these, the other 19 concerned the sigmoid flexure Spassokukozki reports 47 cases of volvulus in 96 cases of intestinal obstruction Braun and Wortmann have grouped the reports of a *number of Serbian authors In 373 instances* of intestinal obstruction, volvulus was observed 127 times

In 53 cases of volvulus occurring among 520 cases of obstruction observed at the Massachusetts General Hospital, Sweet reports the *following incidence of the various* types of volvulus 36 were observed in the small intestine, 67 9 per cent 10, or 18 8 per cent, occurred in the sigmoid flexure, and the remaining 6 *concerned the cecum,* 11 3 *per* cent Jacobsen found volvulus of the cecum and torsion of the small intestine to be most frequent among a group of cases of volvulus seen at the Viborg Hospital in Denmark In 102 cases seen at the Friedrich shain Hospital, Braun and Wortmann list the following occurrence Small bowel, 56 cases, sigmoid flexure, 31 cases, cecum 7 cases small bowel and cecum, 4 cases, simultaneous torsion of cecum ascending colon and transverse colon, 2 cases and one instance of isolated torsion of the transverse colon and another of the stomach



Fig 123—Volvulus of the sigmoid flexure necropsy specimen (Christopher s Textbook of Surgery W B Saunders *Co* 1936 *p* 1220 *Courtesy Dr* N F Lufkin)

Sigmoid Flexure

All writers stress the greater length of the intestine and the significance of vegetable diet amongst Russian and Serbian people as contributing factors to the frequent occurrence of volvulus of the sigmoid flexure Curschmann found abnormally long flexures of the sigmoid in only 4 2 per cent of postmortems made in Germany, whereas Samson, in similar material in Russia found unusually long sigmoid flexures in *20 per cent* Brehm observed these abnormally long sigmoid flexures to be more common in males than females while Laurell states that they are equally as frequent in women as men In necropsy material Wessel (quoted by Fernstrom) found sigmoid flexures reaching above the umbilicus in 38 per cent *of men and 48 per cent of women (68 autopsies)* Fernstrom states that torsion of the sigmoid flexure occurs four times more frequently in males

Strong muscular men more frequently than others fall victims to the disease Laurell believes that the lesser capacity of the abdominal wall renders the occurrence of spontaneous reposition of volvulus less com

mon in men than in women The wider pelvis of the female and the relaxed abdominal walls occasioned by frequent pregnancies permit of greater room in the abdomen and probably of a better chance of spontaneous reduction, but at the same time these conditions would appear to encourage freer movement and a greater liability to the development of torsion

The greatest incidence of volvulus of the sigmoid flexure occurs in middle and advanced years In 119 such cases collected from the literature, *Gifhorn observed the following age distribution*



Fig 121—Volvulus of cecum Owing to lack of mesenteric fixation of cecum repeated attacks of obstruction occurred There was a 360 clockwise twist in the cecum about at the point of entry of the ileum which is moderately dilated

Table XXXIX

Age Incidence of Volvulus of the Sigmoid Flexure

10-30 years—14 cases
31-50 years—46 cases
51 70 years—40 cases
71 90 years— 8 cases

Cecum

Lecène comments upon the rarity of volvulus of the right colon and in 1910 says that he could find but four other cases reported from all of France Taltin in Finland reported 28 cases in the five year period between

1897-1902 Faltin gave as explanation for this extraordinary frequency the large vegetable diet (especially potatoes) eaten there Volvulus of the cecum is only possible in the absence of fixation of the cecum or in the presence of a mesocecum and mesocolon sufficiently mobile to permit of torsion (Fig 124) In such cases the cecum usually exhibits a continuation of the mesentery possessed by the terminal ileum Many cases present in addition, failure of complete rotation of the right colon (Rixford)

Harvey noted unnatural free motion of the cecum and ascending colon *in 13 3 per cent of examinations performed upon 105 infants at necropsy* Chalfant stated that unusual mobility of the cecum and ascending colon were present in about 20 per cent of persons of all ages

Small Intestine

Volvulus of the small intestine owes its origin to defective fixation of *the mesentery, there being frequently but a small pedicle from which* the small intestine derives its blood supply The process of rotation of the bowel and mesenteric fixation is described in another chapter (p 421) Volvulus in the absence of mesenteric fixation has occurred in newborns and Dott has described this occurrence as volvulus neonatorum When the small intestine and cecum have a common mesentery, a portion of the right bowel usually participates in the torsion Volvulus of *shorter segments of the* small intestine may be occasioned by the presence of narrow adhesive bands Wilms and Kallio have lent this type of intestinal strangulation considerable prominence under the caption of "knotting" of the intestine Abnormal mesenteric bands are occasionally present in incomplete intestinal rotation and defective *mesenteric fixation* Tumors of the small intestine may initiate torsion and volvulus of the bowel (see Fig 125)

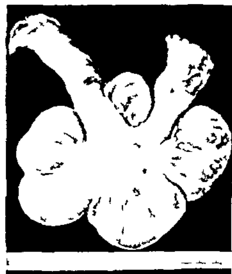


FIG 125—Enterocystoma of jejunum causing volvulus Detorsion and primary closed resection were done

Stomach

Volvulus of the stomach occurs in the ptosed hypermobile stomach Overfilling and gaseous distension are frequently contributory factors Torsion of the stomach occurs occasionally in diaphragmatic hernias, in the presence of tumors in the stomach, inflammatory processes in the vicinity of the stomach, and in the presence of displacements of other contiguous viscera (Payr)

B PATHOLOGY

Torsions of 180° to 360° are usual, but in cecal torsion and volvulus of the small intestine, twists of 520° to 720° may be seen With broad mesenteric attachments, a twist of more than 180° is unusual The tightness of the twist rather than the number of turns determines whether the pathologic changes of tissue necrosis will follow Mesenteric cysts occasionally give rise to torsion of the intestine and volvulus of a portion of the small intestine may occur when a gallstone blocks its lumen The nature of the content of the torsioned loop is subject to considerable variation In incomplete obstructions or those in which the torsion develops gradually, both gas and fluid may be found in quantities within the strangulated segment, in consonance with the experimental observation that a loop of gut cut off from the oral source of swallowed air or a closed loop will have little gas in it Similarly, when complete occlusion of the bowel is established by torsion, the fluid within the loop will usually exceed the gas present Free peritoneal fluid, hemorrhage into the bowel, and infarction of its wall, gangrene, and perforation of the twisted segment with associated peritonitis are natural sequelae of the occurrence In volvulus of the sigmoid, developing commonly more insidiously than cecal and small intestinal torsion, dilatation of the proximal segment is also frequently present

The direction of the twist in torsion of the small intestine is usually clockwise though counter clockwise twists are observed Similarly, torsion of the cecum is usually clockwise but Faltin, in 47 cases found 27 to be clockwise and 20 counter clockwise Both varieties occur also in the sigmoid, but the clockwise twist is the more frequent

C CLINICAL FEATURES

Sigmoid Flexure

In volvulus of the pelvic colon, abdominal distension usually dominates the picture The strangulated loop frequently stands out prominently and occasionally, can be outlined as an elastic mass beneath the abdominal wall This stiffening of the bowel, frequently described as Wahl's sign, is significant of the presence of an infarcted gut in which hemorrhagic infarction due to venous occlusion occurs in consequence of the torsion With volvulus developing more slowly, enormous gaseous distension of the twisted loop is more likely to be made out on percussion or noted on a skiagram In torsion of the pelvic colon, antecedent lesser attacks of pain and a story of obturate constipation are not infrequent Tenesmus and bloody mucus in the rectum are not infrequent The signs of a mechanical obstruction, viz , severe crampy pain nausea, and vomiting and intestinal borborygmi are invariably present *Intestinal colic* and a tender abdomen indicate that a strangulating obstruction is present When the loss of blood into the infarcted segment is great, shock is usually in evidence

Fernstrom recognized three types of volvulus in the pelvic colon (1) the acute type, (2) acute recurrent attacks of short duration, and (3)

the chronic atypical, with slight or moderate pain Patients with a long pelvic flexure, who are subject to constipation and periodic attacks of pain relieved by an enema, in which a barium study reveals no intrinsic lesion in the bowel, may fall into Fernstrom's third type of atypical chronic volvulus He states that he had administered barium enemas during such attacks of pain and has found the opaque mixture to stop abruptly at the beginning of the pelvic colon Subsequent progress of the barium into the pelvic loop frequently stops the pain Larimore states that patients with this type of disorder frequently have an achlorhydria The potential for the occurrence of torsion is apparent in the accompanying film of a patient who was subject to frequent attacks of abdominal pain such as that described above (Fig 126)



Fig 126—Configuration of the sigmoid flexure in recurrent volvulus in a patient complaining of frequent attacks of abdominal pain associated with meteorism the potential for volvulus is apparent

Determination of the capacity of the colon, by permitting as much water to run in under the force of gravity as the patient will tolerate, is frequently mentioned as a sign of diagnostic import in volvulus of the sigmoid flexure Ordinarily, three to four liters of water can be introduced into the unobstructed colon of the adult without difficulty and occasionally as much as six, inability to introduce 500 cubic centimeters of water has been considered of diagnostic importance for volvulus X-ray evidence of gaseous distension as observed on the scout film of the abdomen or the barium enema would give more reliable information

Volvulus of the Small Intestine and Cecum

The symptoms of these two disorders, in the main, are quite similar As related above, their occurrence is predicated on the same etiologic agent, viz, inadequate mesenteric fixation The obstruction of the small intestine in this type of volvulus gives rise usually to copious and frequent vomiting In a twist involving the entire small intestine, distension may concern only the stomach and duodenum the occluded and strangulated segment being essentially gas-free Incomplete occlusion, however, may give rise to enormous gaseous distension Codman refers to a patient with volvulus of the small intestine in which the distension was considerable but the patient after vomiting initially failed to bring up any more content from the stomach This observation he feels should suggest the pos

sibility of torsion of the small intestine In the main, the symptoms are more acute in volvulus of the cecum or small intestine than in torsion of the pelvic colon Yet, chronic types of these varieties of volvulus have also been described (Poynton, Liebe, Baumler)

D DIFFERENTIAL DIAGNOSIS

Mesenteric thrombosis, acute pancreatitis, peritonitis, and strangulation of an internal hernia from some other cause, may mimic torsion of the bowel very closely Pre operative differentiation is less important than recognition of the fact that tenderness, peritoneal irritation, moderate rigidity, and disten ion point unequivocally to the presence of a surgical lesion The presence of *intestinal colic* in volvulus helps to exclude non obstructive disorders Dott believes that the following will serve to identify volvulus of the small intestine (1) The signs of bowel obstruction accompanied by the vomiting of bile (2) Distension of the upper abdomen from dilatation of the stomach and duodenum with a flat lower abdomen (3) Presence of blood stained mucus in the rectum

In the infant or new born, presenting symptoms and signs of intestinal obstruction, volvulus of the small intestine is to be considered as a likely possibility For apart from congenital intestinal atresia, it is the only frequent cau e of intestinal obstruction in the new born and young infant Ladd has pointed out that atresia is likely to be accompanied by considerable vomiting from the start whereas, in volvulus vomiting and symptoms of obstruction are more likely to occur after the lapse of some weeks after birth Failure of rotation of the bowel in which condition the small intestine lies on the right side of the abdomen, and the colon on the left, is a common cause of volvulus of the small bowel The occurrence of ob dominal pain and distension in a patient having this condition should conjure up in the examiner's mind the possibility of volvulus of the small intestine The presence of a mass, in the mid abdomen accompanied by signs of intestinal obstruction attended by tenderness, should suggest the possibility of volvulus My associate Dr Clarence Dennis, made the diagnosis in a recent case, on this basis (see Fig 125)

From volvulus of the sigmoid flexure producing obstructive rather than strangulating symptoms, colitis has to be differentiated Discharge of bloody mucus from the rectum is occasionally observed in volvulus but the signs of mechanical obstruction to the continuity of the intestine dominates the picture, whereas, in colitis, these are either totally absent or remain well in the background Stenosing carcinoma of the sigmoid must be considered in the differential diagnosis of torsion of the sigmoid flexure Endoscopic examination of the bowel, a barium enema, and the absence of strangulating phenomena in carcinoma help to establish a preoperative diagnosis In carcinoma of the sigmoid colon causing obstruction tenderness if present is more likely to occur over the cecum because of its distensibility Volvulus concomitant with carcinomatous obstruction at the flexure does occur

E TREATMENT

The treatment indicated for torsion of the intestine is early *operation* and liberation of the strangulated segment When the operation is done soon after the symptoms appear, simple untwisting of the strangulated *segment* is all that is necessary Evisceration of the strangulated loop through an adequate incision facilitates detorsion Puncture and aspiration of the contents of the twisted loop may have to be done as a preliminary measure The presence of considerable distension calls for drain

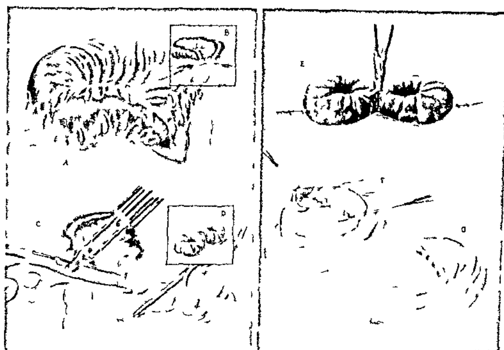


FIG 127—The exteriorization operation (Bloch Paul Mikulicz) for volvulus of the colon A The exteriorized bowel after detorsion Occasionally the bowel has to be aspirated in the manner shown in Fig 47B to permit detorsion B Approximation of the adjacent limbs of the bowel C The exteriorized devitalized bowel is amputated on completion of the operation Note the presence of a catheter in the proximal limb of the colon to obviate tension in the bowel D The resultant external stomas after the small crushing Payr clamps drop off (usually about the 8th postoperative day) E The spur is crushed before the patient leaves the hospital It takes about 7 or 8 days for the large Ochsner forceps to cut through F and G Closure of the colostomy

age of the bowel Where the vascular occlusion has been of severe degree and has existed for some length of time, circulatory changes in the intestine necessitate the performance of a more formidable procedure When the intestine fails to show signs of viability, excision or exteriorization must be performed

In torsion of the sigmoid flexure that has progressed to devitalization, exteriorization by the Bloch Mikulicz technique is the operation of choice with immediate opening of the bowel upon completion of the operation If the bowel is of questionable viability, exteriorization with proximal

colostomy would appear to be the best operation In cecal volvulus, detorsion and exteriorization of the damaged cecum and cecostomy may be considered the operative procedure of choice in instances in which the bowel is non viable Yet primary re ection with immediate closed anastomosis, if the distension is not too forbidding, is probably an even better operation In volvulus of the small intestine, if after detorsion the bowel is found to be non viable, a primary resection and anastomosis is to be preferred to exteriorization in those instances in which the greater part of the small intestine is concerned Doerfler s very extensive primary resection of the bowel referred to on page 456 was performed for volvulus of the small intestine I add has well described the manner of performing detorsion for volvulus of the small intestine in infants and children

It is well known that following detorsion, a number of instances of volvulus of the sigmoid flexure re occur Finsterer reports 13 recurrences amongst 47 cases of volvulus of the sigmoid flexure when detorsion only was done Obalinski, von Eiselsberg and Philippowicz have all seen recurrences of volvulus of the sigmoid flexure after detorsion and stress the necessity for more radical therapy Bloodgood reports two such cases, one had been operated upon in his first attack at which time the torsion was reduced This patient had 32 attacks during the following 16 years After the thirty second seizure, Bloodgood excised a portion of the sig moid and made a lateral anastomosis with complete relief for the patient

Makins reports an instance of idiopathic dilatation of the sigmoid flex ure upon whom six operations were performed The whole repertory of sur gical procedures had been practiced with the single exception of colostomy Colopexy, plication and lateral anastomosis had all been made without effect certainly the performance of entero anastomosis between two dis tended segments of such a loop is not to be recommended Colopexy, and plication of the mesentery as well as of the bowel itself seem to be uncertain methods in the treatment of the condition Exteriorization with excision of the greater portion of the loop concerned or primary resection by the closed method is the method of choice in recurrent cases The potential for recurrence of volvulus of the cecum or small intestine also ob tains unless more adequate fixation of the wall of the cecum or of the mesentery of the small intestine is provided

F MORTALITY

The mortality of operations for volvulus has been unusually high, but has its explanation in the fact that most cases come to operation late Philippowicz reports 43 cases of volvulus of the small intestine patients presented themselves for operation on the average on the fifth day of their complaint In the 36 cases in which torsion of the root of the mesentery occurred 13 recovered (36 per cent) two however were too ill to be submitted to operation Bundschuh has collected 110 cases of cecal volvulus from the literature, 23 died without operation Of the 87 submitted to operation, 52 cases (60 per cent) died

For torsion of the sigmoid flexure the results are somewhat better the syndrome being more easily recognized and strangulating effects occurring

less frequently Perthes reports a 39 per cent mortality Of the 39 cases of volvulus of the sigmoid submitted to operation reported from the *Russian surgical clinic of Rubaschew* by Perlmann, there were 18 deaths (46 per cent mortality) In the cases in which gangrene was present necessitating excision, the mortality was 80 per cent Muschkatin has recently reported seven cases of torsion of the pelvic colon all of which, but one, recovered after operation He exteriorizes the strangulated loop and anchors the viable ascending and descending limbs of the colon in the wound The devitalized portion is excised and a primary end to-end anastomosis is made The mesentery from the strangulated loop is saved and is sutured over the anastomosis, which is then left beneath the skin because of the risk of fistula formation He believes that this method is to be preferred to a two stage resection by the Bloch Mikulicz method (Fig 127) Koster (1940) has advocated, recently, extraperitoneal placement of the anastomosis, after colonic resection for malignancy Whereas, such a procedure may have some justification, when primary anastomosis is performed for colonic obstruction, it would appear that extraperitoneal placement of the anastomosis in unobstructed cases suggests that the surgeon has little confidence in his capacity to make a satisfactory anastomosis

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Chapter XXI

INTUSSUSCEPTION

A FREQUENCY

The incidence of the occurrence of intussusception in the various quar ters of the world varies considerably Souttar (London) states that 20 per cent of all cases of intestinal obstruction are cases of intussusception Invagination constitutes a fairly large proportion of all cases of intestinal obstruction in England, Denmark, and Australia, however, it appears to be definitely less frequent in the United States and Germany

About 75 per cent of all instances of the disease are seen in children under two years of age—more than one-half of the cases occurring in the first year of life, and most of these are observed between the fourth and ninth months of life The remaining 25 per cent divide themselves throughout the years, being more frequent in early childhood than in later years

Among 400 cases seen over a period of 18 years from 1903 to 1920 inclusive at the London Hospital, Perrin and Lindsay found 314 cases (78 5 per cent) in the first two years of life, 279 cases (66 75 per cent) were under one year of age There were only 18 cases more than 14 years of age in this series Of the 400 cases, 203, or slightly over 50 per cent, occurred between the ages of five and nine months Two hundred seventy two cases (64 per cent) were males and 128 cases (36 per cent) were females

The disease usually affects healthy infants An abuse of cathartics is said to be causative, but Monrad says that, in Denmark this explana ion can not be said to account for the high incidence of the disease ob served Whereas in adults a tumor or a Meckel s diverticulum is often present as the etiologic factor in the genesis of the intussusception al most invariably in infants no apparent cause is found Enlargement of Peyer's patches of lymphoid tissue in the terminal ileum has been as cribed as a frequent cause of invagination by many authors, particularly Walton, Hipsley, and Clubbe Walton states that the lymphoid tissue forms a ring about the ileocecal valve corresponding to the sacculus rotundus of lower animals Though this is the segment of intestine usually involved in intussusception the greater frequency of the disease in males can scarcely be accounted for on this basis Lymphoid tissue elsewhere in the body reaches its greatest growth at about eleven years (Boyd), and it would be logical to assume that if Peyer's patches of lymphoid tissue followed the same growth curve there would be a large num ber of cases of invagination occurring in the early teens

Matti has suggested that the frequent occurrence of the ileocecal type of intussusception is due to the fact that vigorous peristalsis is countered by antiperistalsis in the cecum A large portion of the cases occur at the

time of weaning from the breast and it is believed that this change in the dietary regime may occasion spasm in the bowel

Nothnagel produced intussusception by stimulating the intestine with a direct Faradic current, Propping produced similar small invaginations in rabbits by administration of physostigmine To all experimental workers in the field of intestinal obstruction, the occurrence of intussusception following severance and inversion of the ends of the upper small intestine is well known Failure to attach the distal segment to a fixed point, such as the abdominal wall in the dog, is frequently followed by invagination of the distal free end and its mesentery distally into the small intestine

My associate Dr Clarence Dennis, obtained three skunks to study the secretory capacity of the cecal appendage Two died of jejunal intussusception before surgical exploration was carried out apparently due to dietary changes The third skunk died of intussusception after exploration The skunk like the bear and the raccoon, has no cecal appendage or homologue of the vermiform appendix of man The small intestine and colon meet without the anatomical landmark of an ileocecal valve and sphincter

In ca es of intussusception observed after the age period during which the occurrence of the disease is frequent, tumors are frequently found as cau ative factors in the development of the invagination Polyps leiomyomas lipomas, fibromas polyposis of the intestine and carcinomas are commonly offending agents and occasionally a cyst or solid tumor of the mesentery near the bowel wall may initiate the invagination Of 45 ca es of fibroma of the intestine collected by Clifton and Landry, 33 caused intussusception Amongst 326 cases collected by Wellington in which a Meckel's diverticulum gave origin to acute trouble necessitating surgical intervention, bowel obstruction was present in 144 instances, of which number 59 were cases of intussusception When intussusception occurs in late childhood or later the presence of a tumor or Meckel s diverticulum is to be suspected Such tumors may occasionally cause intussusception in nurslings

Eliot and Corscaden analyzed 300 cases of intussusception in adults, a tumor was found in the bowel in 40 per cent of the cases of which 24 per cent were benign and 16 per cent were malignant Ulceration in the bowel of tuberculous bacillary or typhoid origin accounted for 14 per cent of the cases of intussusception In 12 per cent a Meckel s diverticulum was present and, in a few instances, the intussusception appeared to have been initiated by trauma Kasemeyer records 284 cases of tumor invagination of which 208 were due to tumors and the remaining 76 to Meckel's diverticulum and other causes Of the neoplasms causing intussusception, 38 per cent were malignant In the remainder of the group, the cause of the intussusception was not apparent

Chaffin Mason, and Slemons have recently collected from the literature 20 cases of intussusception as ociated with pregnancy The writer has once noted this occurrence It concerned a short enteric intussusception during the sixth month of gestation

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through the ileocecal valve and the pure enteric are small intestine invaginations A rare type of invagination, of which Huddy has collected 68 examples, is intussusception of the appendix in whole or in part into the cecum in the manner of inversion of the finger of a glove They occur more frequently in childhood than in later ages Christopher (1938) reports a recent successful case and states that 80 cases are to be found in the literature In the Italian literature there have been reports of invagination of the haustra of the cecum (Grasso Sovena 1910) Some of these the writers say, have gone on to gangrene

Other atypical intussusceptions are to be mentioned such as the invagination of one or both loops of the jejunum through a gastrojejunotomy stoma into the stomach Chamberlin (1940) reports successful reduction of a recurrent jejuno gastric intussusception through a gastrojejunostomy stoma

Reports of more than 40 such cases are to be found in the literature In a patient for whom the writer did a gastro jejunostomy in 1925 for chronic duodenal ulcer and excision of a segment of small intestine just beyond the duodenojejunal flexure in 1929 for a chronic bowel obstruction occasioned by collection of intestinal content in a number of diverticula on the mesenteric border of the bowel this accident happened one month following dismissal from the hospital after the last operation The diagnosis was made by Dr Rigler roentgenologist to the University Hospital and is well supported by the accompanying film (Fig 129) The patient refused operation and subsequent examinations made showed spontaneous reduction to have occurred The operative mortality in early reductions is said to be about 10 per cent (Bettmann and Baldwin) A few instances of intussusception of the stomach into a dilated duodenum have been observed in the presence of a tumor in the stomach (Hen chen) Gastric polypi on a pedicle in the antral area of the stomach may protrude into the duodenum and obstruct periodically or initiate obstruction by bringing intussusception about



Fig 129—Retrograde intussusception of jejunum through gastrojejunostomy stoma The filling defect in the stomach indicates the jejunum The patient refused operation and the invagination was reduced spontaneously

C TYPES OF INTUSSUSCEPTION

Though some indication may be present the exact anatomical variety can only be determined with accuracy at operation on reduction of the

Spastic obstruction occasionally is the initial forerunner of invagination of the bowel Intestinal worms, especially the Ascaris, have been known to cause intussusception (See obturation obstruction chap 14) Rost was able to isolate from worms a substance that produced vigorous peristalsis in the intestine of the cat

In South Africa, where infestation of sheep with the larvae of Oesophag

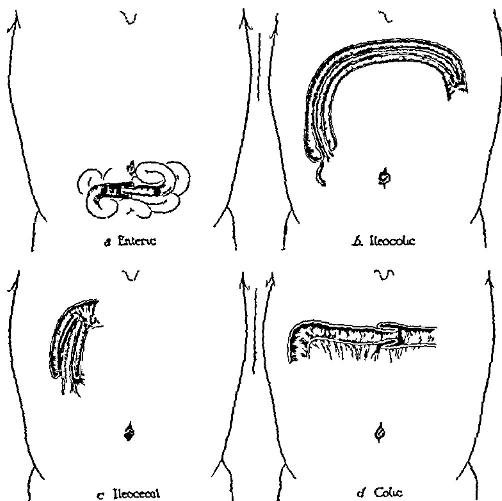


FIG 128—The various types of intussusception (Radiology 17 44 1931)

ostoma in the intestinal wall is common sheep are commonly affected with *intussusception (Marek)*

B PATHOLOGY

Cases of intussusception may be divided into two main groups, viz, large and small intestinal invagination each again divided into two sub groups The ileocecal in which the caput ceci forms the apex of the invaginated bowel and the pure colic, constitute the intussusceptions of the large intestine The ileocolic in which the lower ileum prolapses

whether such transient intussusceptions form occasionally and reduce themselves in the postoperative period

Agonal intussusceptions are usually of the ascending variety They are very short and are frequently multiple They exhibit no inflammatory reaction in the bowel wall and are easily reduced They are probably caused by tumultous contraction of the bowel in response to asphyxia of the tissue

D MANNER OF GROWTH

"The growth of an intussusception occurs exclusively at the neck The apex of the intussusception soon becomes edematous, stiff, and swollen, and once this has happened it is impossible for the apex to change The driving force is supplied entirely by the ensheathing layer or intussus cipiens As in normal peristalsis, the circular fibers of the sheath contract strongly above, driving the intussusception on and forming a fixed point from which the longitudinal fibers can act These act in one of two ways If the sheath is loose, they pull it over the intussusception like a sleeve If it is tight, they drive the intussusception into it This is the only way in which an intussusception can grow" (Souttar)

It might appear that the drag of the mesentery between the entering and returning layers would limit progression of the invagination The mesentery, however, is attached about the center of a horseshoe, formed by the large intestine, and from this center the mesentery swings round like the hand of a clock modifying the elongation required In infants, the peritoneal attachments of cecum and ascending colon are incomplete permitting of greater displacement The great mobility of the colon in infants may allow of the protrusion of the ileocecal valve through the anus where it may be identified by the orifice of the appendix Bonomini (1938) states that, the longer mesentery permits a greater length of invagination a thick short mesentery on the contrary offers less opportunity for the development of a long intussusception Bonomini observes also that the nearer the entrance of the intussusception to the root of the mesentery, the greater is the opportunity for a greater length of invagination

E PATHOLOGICAL CHANGES

The obstruction in intussusception is afforded by the active contrac tion of the sheath and especially at its neck An actual block of the lumen does not exist The continuity of intestinal lumen between oral and distal segments remains intact and in chronic intussusceptions in which the bowel wall changes are not as marked, the intestinal current is preserved

The greatest alteration in the bowel in acute intussusception occurs in the intussusceptum The walls of the invaginated segment become rapidly edematous stiff and engorged with blood and extravasation of blood into the lumen occurs The mucus appearing in the stool has its source in the activity of the mucous glands in the strangulated intus susceptum Acute intussusceptions tend rapidly to become irreducible

invagination In the ileocolic variety, the vermiform appendix and a portion of the cecum remain external to the invagination in contrast to their internal situation in the ileocecal type When the ileocolic variety is completely unfurled, it is apparent that some of these are double or compound, i e , a pure enteric type of invagination started at a short distance from the cecum, rarely more than six inches away and this intussusception has become invaginated into the cecum or ascending colon

Whereas, the usual intussusception consists of three cylinders, viz , internal and returning layers, constituting the intussusceptum and the outer tube known as the intussuscipiens, a double intussusception presents five cylinders and as many as seven *may be present in a compound intussusception*

Table XL —Incidence of the Various Types of Intussusception

	Fitzwilliams	Perrin and Lindsay	Clubbe
Year	1908	1921	1921
Total number of cases	648	335	253
Variety of intussusception	Per cent	Per cent	Per cent
Ileocecal	60 8	46 5	57 6
Ileocolic	25 6*	37 6	31 8
Enteric		10 1	8 8
Colic	7 3	5 6	2 0
Multiple and double	6 1	—	—

* Includes also enteric intussusception

Agreement is not absolute amongst all observers as to which is the most common type of intussusception By far the majority of instances of intussusceptions in children occur about the ileocecal region A few contend that the ileocolic variety is most frequently found, whereas in practically every large series, ileocecal invaginations are the most numerous as table 40 attests

Intussusception is almost invariably of the descending variety, a portion of the intestine being invaginated into a more distal segment Kausch observed an instance of ascending invagination of the intestine in 1921 and collected 41 similar instances from the literature Groper (1940) reported a recent successful reduction of an ascending intussusception and reviewed the literature on the subject D Arcy Power has observed a descending and *an ascending intussusception in the same individual* Buckley reports superimposition of a retrograde upon a descending intussusception Just before closing the abdomen after a tedious and difficult gastric resection, the writer has twice observed an enteric intussusception which had developed during the course of the operation In one instance, the tumor was hard and was not reduced easily There was no obvious cause of the invaginations and both patients recovered One wonders, naturally,

whether such transient intussusceptions form occasionally and reduce themselves in the postoperative period

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owing to the changes in the intussusception Ulceration, gangrene and perforation of the invaginated bowel may occur in irreducible intussusceptions The intussuscipiens rarely shows significant gross changes It is not infrequently congested and may exhibit deposits of fibrin or other evidence of local peritonitis Occasionally it may even perforate consequent upon the pressure of the invaginated bowel upon it In chronic intussusceptions, the ensheathing cylinder is often thickened The bowel above the obstruction is usually dilated somewhat and presents evidence of congestion In chronic invaginations the proximal bowel may undergo considerable hypertrophy

F CLINICAL FEATURES

There are four cardinal symptoms of intussusception (1) periodic attacks of pain, (2) vomiting, (3) passage of mucus and blood by rectum, and (4) presence of a palpable tumor in the abdomen

Pain

Pain and vomiting are practically constant in occurrence The sudden onset of painful seizures in a previously healthy baby is a peculiarity of intussusception After a little, the infant seemingly recovers and regains its cheerfulness and carries on as usual, if old enough it resumes play In a little while the infant cries as if in pain, and then alternating pain and relief occur again and again The infant usually does not appear particularly ill Monrad says that the child suffering from pain in intussusception is remarkably pale and has a characteristic apathetic facial expression that is almost typical Occasionally the pain is so severe that the infant appears in a state of collapse, emitting now and ther a feeble moan, which times the occurrence of the pains

The late Dr Amos Abbott of Minneapolis, a keen observer whose experience in the surgery of children was considerable wrote as follows concerning the pain of intussusception "These recurring pains with periods of relief, the writer regards as the most conspicuous and unmistakable of symptoms The outcries accompanying the pains are peculiar and vary from a little cry or grunt to a subdued moan I have never heard one of these little ones scream Especially noticeable are their grotesque gestures and postures, such as creeping about with the hands on the abdomen or boring into the pillow with the head, the child taking the knee chest position the child may roll face down on the floor or throw itself across its mother's knee The sudden relief between the pains is equally striking, the pains last from one half to three minutes rarely more than two with a longer interval of relief These pains are almost as regular in periodicity as labor pains"

Vomiting

In his cases, Abbott found that 100 per cent vomited initially, but that in 81 per cent vomiting was not resumed until after the second day In

patients sent to the University Hospital for operation for intussusception the temporary cessation by vomiting for 12 to 24 hours or more has often been the factor that has led to delay Continued vomiting is not to be looked for in intussusception, though it may obtain, it is not the usual occurrence

Blood

Blood and mucus in the stool are almost invariably early occurrences Clubbe states that in 97 per cent of the cases observed by him blood was passed per rectum in from 2 to 10 hours The pure colic intussusceptions constantly have blood in the stool early Enteric invaginations may not present blood in the stool There is often in intussusception the story of frequent straining and tenesmus with passage of only a little mucus or blood Rarely blood may be vomited Monrad noted its occurrence twice in ileocolic intussusception

The following table gives the frequence and time of appearance of blood in the stool in patients seen by Monrad

TABLE XII—TIME WHEN BLOOD WAS PASSED AFTER THE ONSET OF THE INVAGINATION (Monrad)

	Type of invagination			
	Colic	Ileocecal	Enteric	Ileocolic
0– 6 hours	19	42	0	5
6–12 hours	1	16	1	2
12–24 hours	1	3	0	6
24–48 hours	0	0	0	5
No blood passed	0	5	5	1
Total number of cases	21	66	6	19

The state of the bowels prior to the onset of intussusception is usually quite normal occasionally however, invagination occurs when the infant has recently been having diarrheal stools

Tumor

An abdominal tumor may fail of being demonstrated though in the majority of instances its pre ence can be detected At the London Hospi tal Perrin and Lindsay state that the occurrence of a palpable tumor was noted in 63 per cent of 400 cases The ileocecal group presented pal pable tumors in 74 per cent the colic in 73 per cent the ileocolic in 60 per cent and the enteric, in only 29 per cent When anesthesia is employed to obtain abdominal relaxation, the number of instances in which a tumor is palpated is very much increased Monrad demonstrated its occurrence in all but six out of 112 cases Clubbe states only twice in the 253 operations that he has done for intussusception has he opened the abdomen without having previously palpated the tumor In ileocecal invaginations, a tumor is usually felt as a banana shaped area lying to

the right of the umbilicus, stretching up toward the right costal margin, it may, however, be present on the left side of the abdomen, as is usual in ileocolic invaginations or may be palpated by digital examination of the rectum, imparting to the examining finger the consistency of the uterine cervix In colic invaginations, the tumor is usually found on the left side of the umbilicus in line with the descending colon Enteric invaginations are always short, small, and very mobile tumors lying in the neighbor hood of the umbilicus If the tumor is concealed beneath the liver or concerns the splenic flexure, and particularly the latter, it may be exceedingly difficult to palpate it even under anesthesia Abbott felt a tumor per rectum in 55 per cent of his cases Not infrequently it may be felt directly inside the external sphincter and occasionally the bowel may protrude through the anus

The tumor of intussusception stiffens with the painful seizures and relaxes when the peristaltic rush is over With succeeding colics, it advances in position and increases in size Abbott believes that tumor formation is an early development in intussusception and states that he observed it as early as three hours after the occurrence of pain in a physician's child The rectal administration of 1 to 1 5 grams of chloral-hydrate to infants in whom the presence of intu susception is suspected, is recommended, particularly where the tumor is not readily palpable This pro cedure increases significantly the number of palpable tumors, in that, it affords a grade of relaxation that is remarkable

The abdominal wall is usually soft in intussusception but may become moderately rigid during the painful seizures, a voluntary rigidity due to contraction of the muscles of the abdominal parietes The absence of tenderness and rigidity is explained by the fact that, the ensheathing layer retains its blood supply, even though the intussusception be gangrenous Distension is a late sign of continued obstruction The abdominal tumor is best palpated in the quiet interval, the alternating consistency of the tumor is very suggestive of its nature At the height of the colic, bor borygmi may also be made out on stethoscopic examination of the abdomen

G DIAGNOSIS

The occurrence of seizures of abdominal pains in an infant accompanied by vomiting and attended by rectal tenesmus and the appear ance of mucus and blood in the stool or upon the examining finger in serted into the rectum, and the associated presence of a palpable abdom inal tumor varying in consistency establishes the diagnosis In most infants the clinical picture is usually quite typical, in older children and adults in whom a definite cause in the way of a tumor Meckel's di verticulum or an ulcer may be found in the bowel, atypical manifestations with an insidious onset or chronic course are more likely to occur

If the mother's story is attentively heard and care is exercised in examining the abdomen the rectum and the motions of the infant, an early diagnosis should be made almost invariably Too often further developments are awaited even though when the physician first sees the infant he suspects an intestinal invagination When the vomiting abates,

mother and physician alike are deluded by this seeming improvement into believing that the condition is becoming spontaneously corrected Persistent blood in the stool, abdominal distension, and manifest progressive decline of the infant as expressed in its appearance compel the diagnosis Such occurrences reveal the frequency with which hope triumphs over knowledge An early surrender of sanguine trust to judgment in such instances will save many lives and the attending physician considerable distress and embarrassment

In a well established invagination the lumen of a segment of the bowel within another can occasionally be made out on an x ray film of the abdomen (Fig 130) Abbott states that he was able in almost every instance to visualize an oblong mass in the abdomen with the fluoroscope When the intussusception protrudes into the colon the administration of a barium enema indicates the site to which the invagination has progressed the column of barium being arrested in its progress by the advancing intussusception A central non filled area in the intestinal lumen of the most proximal penetration of the barium corresponds to the intussusception The presence of gas in the proximal small intestine of these infants is of no particular significance for it appears to be a normal occurrence up until about three years of age



Fig 130—Demonstration of intussusception by roentgen examination Coils of small intestine can be visualized in the ascending colon

The diagnosis of intussusception can be almost invariably made early by a careful elaboration of the history and critical evaluation of the physical findings X ray evidence is to be looked upon as an ancillary aid that is not essential to the diagnosis but which may be of great value in atypical cases With the exception of enteric invaginations reliable information may be obtained by the rectal administration of barium in most instances In any case, in which the diagnosis remains in doubt, a barium enema should be given In the colic, ileocecal, and ileocolic varieties, a filling defect in the colon becomes apparent In the enteric variety unfortunately no information is obtained by its employment and it is just in this type of intussusception that help is most needed for the appearance of blood in the stool is a late occurrence and the tumors being small are often not palpated

H CHRONIC INTUSSUCEPTION

Inversion of the bowel does not uniformly eventuate in acute obstruction and strangulation of the telescoped segment of bowel Congestion and edema are the factors that produce obstruction and strangula-

the right of the umbilicus, stretching up toward the right costal margin, *it may, however*, be present on the left side of the abdomen, as is usual in ileocolic invaginations or may be palpated by digital examination of the rectum, imparting to the examining finger the consistency of the uterine cervix In colic invaginations, the tumor is usually found on the left side of the umbilicus in line with the descending colon Enteric invaginations are always short, small, and very mobile tumors lying in the neighbor hood of the umbilicus If the tumor is concealed beneath the liver or concerns the splenic flexure, and particularly the latter, it may be exceed ingly difficult to palpate it even under anesthesia Abbott felt a tumor per rectum in 55 per cent of his cases Not infrequently it may be felt directly inside the external sphincter and occasionally the bowel may protrude through the anus

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timately intermingled and the stool has a pronounced fecal odor. Both fever and constitutional disturbance are marked from the onset of the illness in enterocolitis.

Henoch's purpura must be differentiated. The subjects of purpura are usually older than those of typical intussusception and other evidences of purpura such as a rash, joint pains, hemarthrosis or hematuria are usually manifest. This disease is frequently associated with abdominal pain, vomiting, diarrhea and melena. The constitutional symptoms usually overshadow the abdominal features, however, and the blood in the stool is intimately mixed with the feces. It must not be forgotten that intussusception may occur during its course. Sutherland was the first to call attention to this occurrence and recorded an instance in which a boy of five with purpura was subjected to laparotomy and only a small hemorrhage was found in the bowel, and another of a girl of seven with purpura in which the presence of intussusception had not been suspected and the girl died. One might suspect that the presence of an abdominal tumor should differentiate, but in a later paper Sutherland refers to two cases in which tumors were palpated, laparotomy done, but no intussusception found. Osler was the first in this country to direct attention to the simulation of intussusception by purpura. Gamstedt has recorded the instance of a 17 year old girl for whom he successfully resected 130 centimeters of the ileum for intussusception during the course of Henoch's purpura. Bailey (1930) emphasizes the importance of operating upon cases of purpura complicated by intussusception, and reports several successful cases. Schwartzmann (1940) has reviewed the subject recently. The writer has observed bowel obstruction from hemorrhage into the bowel in a hemophiliac who responded satisfactorily to suction (1933 Case B V). The Platous (1940) have reported another hemophiliac whose obstruction responded satisfactorily to suction.

Appendicitis may give rise to confusion. Under two years, when intussusception is frequent, appendicitis is exceedingly uncommon. In appendicitis a tumor does not form nearly as quickly as in intussusception and bloody stools are absent.

Mesenteric thrombosis or embolism may occasionally simulate the clinical picture of invagination of the bowel. The age incidence, however, is entirely different; the majority of instances of mesenteric vessel occlusion concerns adults. A tumor rarely appears in the latter and bloody stools are also less frequent.

In differentiating rectal prolapse from ileocolic invaginations in which the bowel actually protrudes from the anal canal, an important differential point is that in the former the digital finger can not be inserted between anal canal and protruding bowel, whereas in intussusception the examining finger may enter the anal canal just peripheral to the protruding bowel.

J TREATMENT

The treatment of election is early reduction of the invagination by operation. The abdomen should be opened under inhalation anesthesia

tion of the bowel Occasionally, the blood supply of the bowel is not vitiated, obstruction is incomplete or absent, resulting in the establishment of the condition of chronic intussusception It occurs more frequently *in adults and often in the presence of a tumor or a Meckel's diverticulum* that serves as the entering wedge for the development of the invagination Instances where a known etiologic agent, such as a tumor or Meckel's diverticulum, are causative, are called secondary intussusceptions Primary chronic invaginations (without apparent cause) also occur and at all ages Goodall has collected from the literature 122 chronic primary intussusceptions in adults, of which number 32 had existed for more than six months, eleven, Goodall stated, had been present for more than one year Pohl relates the remarkable instance of a boy who died of a chronic intussusception which the author conjectures had been continuously present for as long as eleven years Barlow and Mottershead (1941) report a successful partial colectomy for chronic intussusception in a patient aged 44 They state it as their belief that the intussusception began in childhood

The symptoms of chronic intussusception are usually atypical In the majority of instances, however, the onset is abrupt as in acute intussusception Still and Stallman have particularly stressed this feature In Goodall s series, the onset was acute in 86 per cent of the cases, attending sudden occurrence of abdominal crampy pain, there was nausea and vomiting *There may be a little blood and mucus in the first motions or* these features may be absent altogether The presence of a tumor that hardens during the pains and relaxes in the free interval should serve to identify the disorder A tumor was palpable in 88 per cent of Goodall s series In the recorded cases wasting has been a prominent feature Visible peristalsis and hypertrophied coils of bowel palpable through the abdominal wall are not uncommon

Enteritis or tuberculous peritonitis have been frequent diagnoses in chronic intussusception in children, in adults, appendicitis and carcinoma of the bowel as well, are common diagnoses The sudden onset and the *varying consistency of the tumor should serve to enable a careful ob*server to make the correct diagnosis in most instances The administration of a barium enema should prove helpful in doubtful cases when the invagination concerns the colon

In 43 of the instances of intussusception occurring in adults, collected by Eliot and Corscaden, spontaneous separation of the intussusception occurred A number of these died later, however of obstruction due to secondary stricture Goodall believes that spontaneous separation is more likely to occur in acute invagination

I DIFFERENTIAL DIAGNOSIS OF ACUTE INTUSSUSCEPTION

Enterocolitis may be mistaken for intussusception In the latter, the passage of blood and mucus by rectum is usually small in amount and frequently has no fecal odor In intussusception blood is not mixed with the stool as in enterocolitis, in which disease blood and feces are in

to permit delivery of the cecum into the wound Often considerable pressure has to be exerted before the very last portion unfolds itself Occasionally a gentle but firm squeeze applied directly over the remaining tumor mass enables the surgeon to complete the reduction with greater ease Just when to leave off squeezing is difficult to decide Tears in the peritoneal coat in the bowel, in difficult reductions of an edematous intussusceptum, are not infrequent Reduction, however, gives much better chance of success with less risk than recourse to resection The slits in the peritoneal coat may be approximated with a fine suture

When the interval following the onset of the disease has been relatively short, reduction of the intussusception is ordinarily accomplished with ease When strangulation has been present for a long time, reduction may be impossible In such instances, the bowel must be dealt with in some other manner When the bowel is no longer viable, excision of the devitalized segment with the establishment of a lateral anastomosis is to be done The fact of the matter is however, that infants in whom the disease occurs with predilection, rarely tolerate excision and lateral anastomosis Up to 1913 Dowd found only 8 cases of successful resection of the intestine for nonviable irreducible intussusception in children under one year of age In the 29 cases necessitating resection in the series of 400 cases of invaginations reported by Perrin and Lindsay, only 9 recovered, all of these patients being more than 3 years of age In his splendid monograph on intussusception Clubbe (1921) states that 19 successful resections for gangrenous or irreducible invaginations in children under one year are known (See below) Goldman and Elman (1940) describe instances of spontaneous reduction of intussusception and collect 30 cases from what they regard as an incomplete survey of the literature It is not an occurrence which should suggest delay, in a typical instance of intussusception

In 1906, Rutherford made a lateral anastomosis and left the irreducible intussusception in a 4 months' old infant Recovery followed Parry and Bullock have each reported similar successful cases in infants Sir Harold Stiles in discussing Parry's case referred to his procedure as a "remarkable and great operation" It would appear that where feasible, it should be attended by much less risk, especially if the anastomosis were done with a Murphy button or other aseptic type of technique In event one feared further advance of the intussusceptum, blocking the stoma, a few stitches could be placed anchoring the entering and ensheathing layers Montgomery has also more recently endorsed this procedure

In adults in whom intestinal fistula is better tolerated than in infants the best procedure in the treatment of gangrenous intussusception is excision of the non viable bowel with anchorage of the open ends in the wound The continuity of the bowel can be established subsequently with greater safety when obstruction is not present In an irreducible and gangrenous intussusception in an infant of 4 months the writer exteriorized the bowel and cut away the telescoped bowel after closure of the skin An extracutaneous end to end union of the bowel was then made It was proposed to return the bowel to the peritoneal cavity after a few

through a short right rectus incision placed a little below the umbilicus, no matter where the tumor presents A short incision permits of easy closure of the abdomen after reduction of the intussusception and entails no risk of secondary evisceration due to interference with healing during convalescence The intussusceptum is to be pushed backward from below, only the most gentle and delicate traction being exerted on the invaginated bowel toward completion of the reduction if necessary The initial portion of the reduction is done within the abdomen, guided only by the

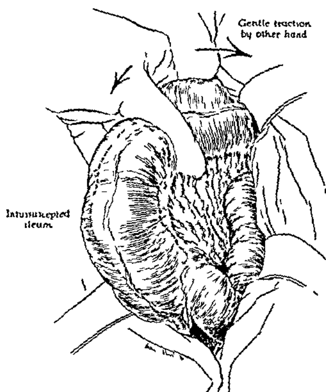


FIG 131—*Operative reduction of intussusception* No traction is put on the ileum but as the intussusceptum is pushed out gentle traction on the ensheathing cylinder facilitates reduction

sense of touch Compression is exerted upon the intussusceptum from below with two fingers of the hand within the abdomen and the pressure of the other hand applied upon the external surface of the abdominal wall Unless the intussusceptum is irreducible it may be pushed back with ease by this means, as far as the cecum When the intussusceptum can not be pushed back in this manner, the incision must be lengthened and the intussusception delivered upon the abdominal wall The bowel has to be returned to the abdomen, however, in order to permit reduction at the splenic and hepatic flexures of the colon The reduction of the apex of the intussusceptum at the cecum is the portion of the invagination that is most difficult and should always be done under direct vision (Fig 131) Occasionally, the incision will have to be lengthened somewhat

Primary resection, granted that the condition of the patient is satisfactory, would appear to be a better procedure

The method of Jesset of dealing with irreducible invaginations in which a longitudinal incision is made in the ensheathing layer, the intussusceptum delivered and amputated and the adjacent cut ends approximated, has little to commend it The danger of peritoneal infection is far too great A method that would appear to possess some merit, in the treatment of irreducible intussusceptions in which no serious circulatory effects are present, is the suggestion of H P Brown of Philadelphia He cuts the neck of the en heathing cylinder with a bandage type of scissors, which division usually permits of extrusion of the remainder of the intussu ception The resulting longitudinal incision i closed by simple suture The writer has never practiced this method and would prefer to do a primary closed resection, in irreducible intussusceptions In a recent paper, Capelle suggests that division of the mesentery of an irreducible intus usception may permit reestablishment of intestinal continuity by reducing edema He would then fasten the neck of the intus susceptum but reports no cases

The following table gives the type of operation with the operative mortality in the 400 cases observed at the London Hospital and reported by Perrin and Lindsay

TABLE XLII —OPERATIVE MORTALITY OF INTUSSUSCEPTION

	Cases	Deaths	Mortality Per cent
Laparotomy with reduction	309	69	22 3
Reduction with appendectomy	18	6	33 3
Resection with anastomosis by clamps*	29	20	68 9
Laparotomy attempted reduction of anastomosis sewn up	12	12	100 0
Resection with Paul s tube	12	12	100 0
Resection with Murphy button	6	6	100 0
Paul s tube	4	4	100 0
No operation			
Resection {Paul s tube / Anastomosis	2	2	100 0
	400	139	34 75

* The 9 cases which recovered were all over 3 years of age

K THE BLOOD LOSS FACTOR

It is to be borne in mind that intussusception is a strangulating obstruc tion in which the loss of blood into the infarcted segment is an item of real importance In all patients, with intussusception, this factor must be taken into account In instances in which the invagination has been present for more than 24 hours, this item attains major importance, for the blood loss may be large in amount If the pulse is hurried it may be taken for granted that arrest of venous outflow from the strangulated segment has isolated enough blood locally to cause actual or potential shock No patient with intussusception should be operated on, therefore,

days, the anastomosis in the meanwhile having apparently healed About the fifth day it broke down, however, and shortly a *complete fistula* was present (Fig 132) It was astonishing to see how little fluid was discharged through the fistulous opening *in this infant* *Not* uncommonly the drainage assumed the character of a normal stool of a milk-fed baby *of that age* When the fistula was closed a few weeks later, its site was found to be about six centimeters from the cecum The infant convalesced uneventfully This experience would suggest that even infants may tolerate well intestinal fistula of the terminal ileum This procedure of exteriorizing the terminal ileum has since been performed successfully in another infant *It may prove that this is the* safest procedure for infants with *late intestinal invaginations which* require radical surgery



Fig 132—Exteriorization of the terminal ileum for irreducible and gangrenous intussusception *in a four month old infant* Remnants of the yeast dressing are seen on the abdominal wall The patient convalesced satisfactorily after closure of the fistula (See text)

The prejudice against the establishment of intestinal fistula in infants may arise largely from instances in which it has been necessary to do a resection in the upper reaches of the ileum Dr F H Scott, Professor of Physiology at the Medical School of the University of Minnesota tells me that not over 350 cubic centimeters of intestinal secretions pass the ileocecal sphincter in a 24 hour period in an adult Intestinal invaginations necessitating radical surgery would, on the whole, be suitable cases for the establishment of such a fistula in that the irreducible portion usually concerns the very terminal ileum Bauer, from the clinic of Leriche, has recently endorsed this procedure and reports two successful instances—neither of which, however was an infant

The closed anastomosis should make lateral anastomosis or primary *resection in irreducible intussusception a feasible procedure* In an irreducible gangrenous intussusception, in an infant of two months my associate, *Doctor Clarence Dennis, performed recently, a successful* primary resection employing the aseptic end to end anastomosis The irreducible *portion of the intussusception concerned the terminal ileum* Alberts (1941) resected the strangulated intestine successfully, employing the open anastomosis *in a newborn infant with intussusception*

An alternative procedure, in certain cases of irreducible intussusception would be to drain the *proximal bowel by enterostomy* *In a* compound invagination having its origin up some distance in the ileum it probably would be wise to place another catheter *into the distal bowel* for purposes of re introducing the escape from the enterostomy drainage Mayo and Phillips report *the use of this method* *The method would* appear to have very limited usefulness It leaves too much to chance

were received with a good deal of skepticism The chairman of the section questioned the possibility of successfully reducing 50 to 60 per cent of intussusceptions without operative intervention

Monrad, Hirschsprung's successor at the Queen Louise Hospital in Copenhagen, has been an equally ardent advocate of this method of reduction Of 84 cases in which taxis alone was tried, 72 were cured and 12 died—a mortality of 14 3 per cent With regard to the duration of the invagination, Monrad abides by the following rules in attempting taxis Reduction may be attempted up to 36 hours for the pure colic form, not after 24 hours in the ileocecal, and not after 12 hours in the enteric variety Monrad advised against attempting reduction in instances of ileocolic intussusception The correct recognition of the type of intussusception present is important when the conservative method of taxis is attempted

Olsson and Pallin have reported 4 cases of intestinal intussusception in children, in 3 of which a reduction was obtained by administration of a barium enema Monrad employs chloroform anesthesia and combines manipulation of the abdominal wall and administration of an enema

Hirschsprung employed a combination of enemas and taxis under chloroform anesthesia and when a first attempt was not successful, he tried it a second and third time Monrad makes only one attempt and only for 5 to 10 minutes, grasping the neck of the invagination with both hands, he then compresses it from one to two minutes to diminish the edema and then holds the neck of the intussusception with the left hand and tries with the right to pull the intussusception back through the intestine

Almost without exception our textbooks of surgery and treatises on the surgery of infancy and childhood condemn the non operative method of reduction as dangerous Recently however Hipsley of Sydney, who to date may boast as good operative results in the treatment of intussusception as have been published has given the non operative method a trial He states that hydro static pressure has not only a decided place in the treatment of intussusception, but that it is absolutely wrong to submit any patient to operation before attempting to reduce the intussusception by injection" Out of 105 cases in which Hipsley attempted reduction with hydrostatic pressure, the method was successful in 62, of which number only 1 died He employs water at a level of three feet, six inches (105 centimeters)

In the method employed by Olsson and Pallin is afforded a visual corroboration of atisfactory reduction—the Achilles' heel' of the manual reduction method, in which the expulsion of a stool must be awaited for confirmation of successful reduction Arntzen and Helsted have reported also employment of the method with success as have Stephens and others Nordentoft (1939) states that reduction of intussusceptions by barium enema is finding increasing favor in Denmark

With the co operation of Dr L G Rigler the writer has had occasion to test the efficacy of the method in a number of instances The late intussusceptions which afford the surgeon difficulty in reduction, the

until the blood volume has been restored by transfusion of blood or plasma in adequate amounts In this clinic, the restorative value of such trans fusions in late intussusceptions has been demonstrated on a number of occasions (See discussion pages 51-55 and page 134)

L MORTALITY

Of the 253 operations performed by Clubbe of Sydney, there were 54 deaths, a mortality of 21 3 per cent Only 6 or 2 2 per cent of all the cases in the series were over two years of age The mortality in the third 50 consecutive cases was 8 *per cent, and of the fourth 50 cases*, only 3 per cent Taylor of Dublin has reported 81 operations for intussusception with only 3 7 per cent mortality Page reported from St Thomas Hospital in London at the same session of the British Medical Association only 9 deaths in 102 operations for intussusception—a mortality of 8 9 per cent These greatly improved mortality rates indicate what results may be obtained with early recognition and operative relief Hipsley of Australia has had 51 successful operations without mortality in cases that submitted to operation when not more than 36 hours had elapsed from the onset of the attack In Hipsley's series there were 4 deaths, 1, in which more than 36 hours had intervened from the onset, 2, in which the intussusception had been present 3 days, and 1, for 4 days The experience of this writer justifies the statement that all cases sub mitted to operation early, recover Restoration of the blood volume before operation by transfusion and use of the closed method of intestinal anastomosis, in practiced hands, should bring about considerably better results in the late cases

M POSTOPERATIVE FEVER

Following the reduction of the intussusception, a large number of the late cases run an unusually high fever as compared with other intra-abdominal operations for the first few days In the London Hospital series of Perrin and Lindsay, 56 1 per cent of the ileocecal and 41 9 per cent of the ileocolic cases exhibited a temperature of 101°, while a tem perature of 102° was reached in 38 7 per cent of the ileocecal and 28 2 per cent of the ileocolic cases The edema in the wall of the intestine and *the liberation of a toxic substance from a damaged bowel wall* Perrin and Lindsay felt to be the causative agents in this pyrexia The writer's impression is that such reactions suggest that the viability of the bowel has been seriously threatened

Unless the patient is an infant an indwelling duodenal tube to which suction is applied, should be used for a few days postoperatively Infants do not tolerate well, the presence of an indwelling duodenal tube, because of the hazard of middle ear infection (see page 171)

N NON OPERATIVE REDUCTION

Hirschsprung gained world wide renown for successful reduction of intussusception by the non-operative method He presented his material in 1903 at the German Surgical Congress where the results of his method

the region of the iliac fossa Cohen reports 4 instances of recurrent invaginations in infants, all under eleven months of age at the time of the first attack, all recovered He referred to 17 other instances reported in the literature

Most of these recurrences did not occur in the same hospital admission Usually the same segment of bowel was concerned, occasionally the recurrence was at a different level Clubbe believes the likelihood of recurrence is so unusual that it is unnecessary to anchor the cecum at the initial operative procedure but recommends its performance for recurrent invaginations involving the cecum It has also been suggested that the terminal ileum be stitched side to side to the cecum to obviate the propensity for the ileum to prolapse into the large bowel (Lamson) In those instances where the mesentery of the small intestine appears unduly long and mobile, reefing and plication have been suggested In the reduction of every acute intussusception many writers have called attention to the importance of pressing out the last cup shaped depression at the apex of the intussusceptum which represents the starting point of the invagination This concavity must be gently pressed out and made convex At operation one may occasionally observe a tendency of the bowel to re invaginate when this dimple is not squeezed out

Most frequently, however recurrent intussusception concerns older children and adults in whom a tumor or a Meckel's diverticulum is the existing factor in the production of the invagination In an edematous bowel following reduction of the invagination small tumors within the bowel are easily overlooked Barrington Ward cites an instance in which a girl of six had been operated upon four times for the reduction of an enteric intussusception At the fifth operation he resected the telescoped bowel and found several tumors in the segment Oughterson and Cheever refer to a patient aged 22 who had four times been admitted to hospital with abdominal pain In one of these admissions an intussusception of the ileum was operatively reduced, on the fourth admission, a resection was done and a lipoma was found at the apex of the intussusception They refer to 12 other such cases reported in the literature including the case of Barrington Ward referred to above Haggard and Floyd record a most unusual instance in which a patient had one reduction of an intussusception and three subsequent intestinal resections for intussusception caused by an adenoma of the bowel A sister of this patient had two intestinal resections and the father three because of gangrenous intussusception

In every invagination occurring after two years of age the presence of a tumor or a Meckel s diverticulum is to be considered Rexwald Brown records the excision of a segment of intestine for intussusception in a 21 month old infant multiple polyps being found in the excised segment Shaw (1939) has reported recently five additional cases of intussusception occasioned by polyposis Repeated attacks of partial obstruction are often to be elicited in the history Inasmuch as the small intestine is so frequently concerned no blood may appear in the stool and a tumor may not be palpated (Lower)

barium enema will frequently chase back, but complete reduction by this means is most unusual It is the writer s impression that in such cases it is scarcely worth while to try it, by the time that the patient comes to operation, a short time later, the intussusception has again advanced to its previous position It is in the early cases that the method has virtue, a few such cases have been successfully treated by the writer with this expedient of conservative reduction with barium controlled by fluoroscopic visualization In this clinic, however, the abdomen is opened to make certain that the intussusception has been reduced completely and to exclude the presence of a compound intussusception (Fig 133) Should one, however, be dealing with an instance of compound intussusception, the filling out of the cecum and regurgitation of barium into the small intestine might cause the examiner to wrongfully conclude that the intussusception had been completely reduced This hazard is a real one, to be certain, observation for an hour or two might help to avoid the pitfalls of this error Yet this contingency should occasion anyone who undertakes to treat intussusception conservatively by this means some misgivings over its safety Taxis and other rough methods of manipulation through the abdominal wall are not to be recommended



Fig 133—Reduction of intussusception by barium in an infant Visualization of barium in the small intestine indicates that the intussusception has been reduced It does not exclude a compound intussusception however

Clubbe employs the enema only as a preliminary measure He finds that in most instances, the bowel may be pushed back to the region of the cecum by its employment, but he feels it unsafe to rely upon it for complete reduction Complete reduction without operation he has accomplished in only 10 per cent of his cases The child is on the table ready for operation and 300 cubic centimeters of water under 8 feet gravity pressure is allowed to run into the rectum If any doubt exists concerning complete reduction of the tumor, the abdomen is opened

O RECURRENT INTUSSUSCEPTION

The recurrence of an acute intussusception is not frequent Clubbe states that he has twice had to re-operate for recurrent invagination in infants Barrington Ward (1928) refers to an instance in which 3 recurrences took place Hipsley records the remarkable instance of a child of 5 months operated upon three times within three weeks each time the apex of the intussusceptum was found to be the tip of the cecum, and on the last occasion Hipsley stitched the cecum to the parietal peritoneum in

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Chapter XXII

ERRORS IN DEVELOPMENT OF THE INTESTINE GIVING RISE TO INTESTINAL OBSTRUCTION (OTHER THAN CONGENITAL STENOSIS)

Embryology A Anomalies of Rotation

In the natural orderly development of the bowel and its mesentery, a number of accidents may occur which may lead to subsequent intestinal obstruction Among these are to be enumerated (1) partial or complete exomphalos or hernia of the umbilical cord due to lack of final fusion of the abdominal walls, (2) persistence in part or in whole of the vitello intestinal duct (Meckel's diverticulum), (3) abnormalities of rotation of the gut (4) inadequate fixation particularly of the small intestine, the bowel being suspended by a narrow pedicle of mesentery a condition permitting abnormal mobility and predisposing to torsion and (5) persistence of holes or defects in the mesentery This latter occurrence has been discussed previously under the caption of Internal Hernia

The process by which the intestine develops its lumen has already been described in chapter XI It may be well for a better understanding of the hazards connected with the assumption of the ultimate position of the bowel to briefly trace here the normal process by which means this end is attained Dott and Keith give unusually lucid descriptions from which accounts the following has largely been derived (Fig 134) The first indication of the alimentary canal is the endodermic vesicle Very early a constriction in the vesicle demarcates the future alimentary canal and its appendages from the extra celomic portion in the yolk sac The vitello intestinal duct establishes the communication With elongation of the embryo the alimentary canal assumes the form of a tube and its subdivisions become apparent The primitive intestinal loop lies at first in a single plane and is suspended by a common dorsal mesentery In the fifth week of fetal life the midgut has become a V shaped tube and shortly later assumes the form of a U loop The midgut loop is divided by the vitelline duct into two segments 1) the prearterial segment embracing the greater part of the small intestine lying proximal to the duct (Meckel s diverticulum) and 2) the postarterial segment from the vitelline duct to the point of juncture of hind and midgut at the mid transverse colon As the blood vessels of the placenta develop lack of further need for the yolk sac causes it to shrivel and the intracelomic portion of the vitello intestinal duct disappears normally at about the sixth week Persistence of the duct leads to the occurrence of Meckel s diverticulum While the U loop of the midgut is still in the umbilical cord in the extra celomic position due to its more rapid growth as contrasted with the hindgut, the intestine assumes an S shaped curve the small intestine lying on the right and the colon on the left. Further, the pre arterial segment—the small intestine grows

acute intestinal obstruction technic of enterostomy and a further account of decompression by the employment of suction siphonage by nasal catheter Arch Surg 26 933, 1933

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testine has been attained This marks the completion of the second stage of intestinal rotation, the midgut loop now having twisted in a counterclockwise fashion on the axis of the superior mesenteric artery through 270° from its original sagittal plane The third and final stage of rotation consists essentially in descent of the cecum and the attainment of normal mesenteric fixation of the entire bowel The mesentery of the colon becomes largely obliterated, the last parts of the bowel to become fixed are the ileum and cecum The small intestine, previously suspended by a narrow pedicle of the superior mesenteric artery, now acquires a wide fan like attachment at the root of the mesentery, owing to fusion of the mesenteries with the posterior parietal peritoneum This phase of intestinal rotation provides protection against volvulus Failure of this fusion to occur invites volvulus The cecum persists in the fetal position over the right kidney until birth when it comes to lie in the iliac fossa This position of the cecum is a feature occurring only in primates adapted to the upright posture (Keith)

Pathogenesis

Anomalies of intestinal rotation concern essentially the second stage of rotation Dott points out that derangement of the first stage of rotation occurs only in the rare condition of extroversion of the cloaca Development of all structures formed from the primitive gut caudal to the vitello-intestinal duct is interfered with and the post arterial segment of the midgut loop remains undeveloped Rotation fails to occur and the prearterial segment—the small intestine—retains its primitive position, ventral to the superior mesenteric vessels

Dott classifies derangements of the second stage of rotation into three groups

(1) non rotation of the midgut loop
(2) reversed rotation of the midgut loop
(3) malrotation of the midgut loop

The first non rotation, is not a rare anomaly and most clinics which are alert to its occurrence have seen several cases The entire small intestine lies on the right side of the abdomen and the colon on the left This occurrence serves to identify the condition either on the roentgen film or at operation The duodenal loop may have attained its normal retro mesenteric position In the typical instance of complete failure of rotation however the duodenum passes downward and to the right from the pylorus lying to the right of the superior mesenteric artery The tendency is for incomplete fixation of the mesentery of the small intestine and ascending colon predisposing to volvulus Despite the aberrant position of the small intestine and the right colon in the experience of the writer the colon from the splenic flexure down has been normal in its disposition

Reversed rotation of the midgut loop according to Dott is an extraordinarily rare condition The rotation of the small intestine occurs through 90° in a clockwise direction In consequence, the transverse colon comes to lie behind the superior mesenteric artery close to the origin of the vessel, and the duodenum lies anterior to the superior mesentery artery at the

more rapidly than the post-arterial segment—the cecum, with the consequence that the small intestine and its mesentery become considerably more elongated This completes the first stage of rotation

Definite jejunal and ileal coils become apparent in the umbilical cord at

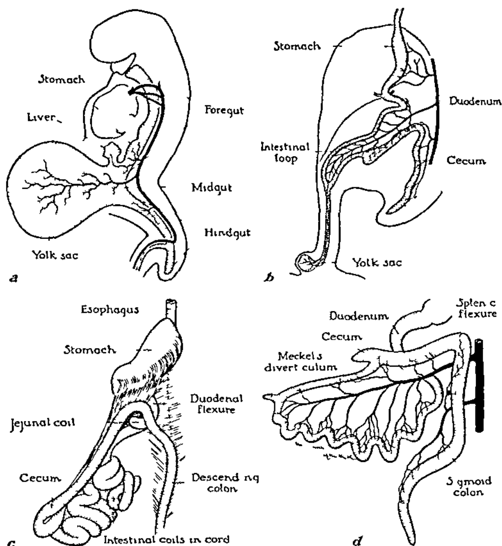


Fig 134—Stages in the development and rotation of the intestine (a) The form of the alimentary canal in a human embryo at the fourth week (b) The alimentary canal and its mesenteries during the sixth week of development (c) The intestinal loop in a fetus in the ninth week (d) Position assumed by the colon after rotation of the gut has taken place (After Keith Human Embryology and Morphology Longmans Green & Co New York 1921)

the ninth week About the tenth week, the midgut returns from the umbilical cord to the abdomen The cecum is the last to return to the peritoneal cavity of the fetus, and as it does so, the colon is carried forward over the superior mesenteric artery of the midgut loop, and at about the eleventh week, the normal postural relationship of the colon to the small in-

ame point Dott was familiar with only two cases which fitted this description One was his own the other a case reported by John Hunter In Dott's case, the small intestine had normal mesenteric relations The cecum and ascending colon had a free and long mesentery Volvulus of the cecum had occurred Dott resected the ascending colon The peritoneal coat of the cecum had ruptured because of the cecal distension and the patient died Since Dott's lucid paper (1923) on derangements of intestinal rotation other cases of this variety have no doubt been published Peignaux and Fruchaud (1930) report the instance of a young girl in whom the colon was found behind the superior mesenteric artery In three successive operative procedures they performed (1) anterior gastro jejunostomy (2) colo colostomy on the transverse colon and (3) colopexy on the right colon

In malrotation of the midgut loop, Dott placed a group of cases presenting irregular defects of rotation not readily classified In some instances the prearterial segment—the small intestine—occupies its normal position and the descent of the cecum into the right lower quadrant has not been complete In others non rotation of the small intestine is present, with an incompletely descended cecum

It is not difficult to picture cases which, on the basis of the differentiations made by Dott, one might have difficulty in deciding whether to place in Dott's group I or III The group II case of reversed rotation in the occurrence of the situation of the transverse colon dorsal to the superior mesenteric artery has a characteristic finding which serves to identify it

Derangements of the third stage of rotation of the midgut loop have to do with failure of cecal descent with fixation of the cecum in the subhepatic position On the contrary however the cecum may descend but fail to secure fixation in its normal position resulting in an abnormally mobile cecum with predisposition to cecal volvulus

Clinical Features of Obstruction Occasioned by Non rotation

Dott has pointed out the great significance of the duodenocolic isthmus or the narrow space over which both the duodenal loop and the colon in the process of rotation come in contact with the superior mesenteric artery Events which occur at this site, are responsible for the types of obstruction which may attend nonrotation and condition the symptoms that may follow Essentially two kinds of obstruction may occur 1 Obstruction near the duodeno jejunal angle occasioned by abnormal adhesions 2 Volvulus of the small bowel and cecum and ascending colon or torsion of any segments of these about the superior mesenteric artery each owing to inadequate mesenteric fixation

The superior mesenteric artery may lie in front of or behind the duodenum These adhesions, which may be m[illegible]ive constrict the duodenum and may give symptoms in the first few weeks of life suggesting that duodenal stenosis may be present Enormous ballooning of the duodenum may occur in consequence of the external compression of adhesive bands The writer has operated upon several instances of duodenal obstruction in which symptoms of periodic obstruction continued from birth into ado-

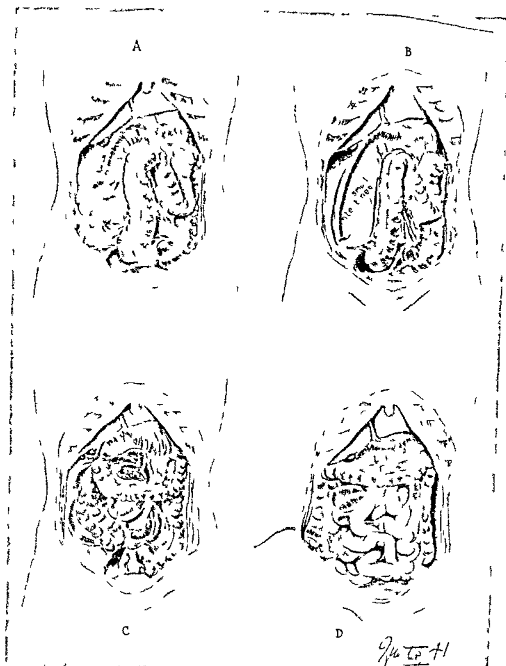


Fig 135—Non rotation of the intestine and the writer's operation to correct the defect The x rays before and after operation are shown in Fig 136 The patient had many attacks of obstruction prior to operation He has remained well (a) The condition noted at operation (b) Incisions to permit freeing of large and small intestine (c) The colon has been mobilized a hole has been cut in the transverse mesocolon to permit reposition of the small intestine into its normal habitat (d) The condition on completion of the operation it is to be noted that complete reduction of the small intestine can not be effected without severing the terminal ileum An end to-side anastomosis between the ileum and the cecum is shown A catheter is threaded into the cecum through the terminal closed segment of ileum and employed as a decompressive vent in the recovery period

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lescence or even adulthood The omentum may also be a factor in this compression Instances have been observed by the writer, in which the omentum went from the stomach to the duodenum—there being no omental attachment between stomach and colon as occurs normally

Volvulus attending failure of complete rotation may make its appearance in the first few weeks of life and has come to be known as volvulus neonatorum In his paper, Dott refers to five cases of prenatal volvulus occasioned by this condition It is known that the fetus swallows amniotic fluid and that the intestine functions before birth The thorotrast studies made by Becker, Windle, and their associates (1940) on the fetus of the guinea pig indicate that, thorotrast injected into the amniotic sac of the fetus is swallowed excreted by the intestinal canal of the fetus and re swallowed again The occurrence of prenatal volvulus is therefore, understandable

Periodic attacks of pain may be suffered by patients with defects in intestinal rotation, due to partial torsion A number of patients may present both aspects of obstruction conditioned by the presence of non rotation viz duodenal compression and torsion of segments of the mid gut loop

Failure of completion of the third phase of intestinal rotation leads to lack of adequate fixation of the bowel and predisposes to the occurrence of volvulus especially of the small intestine and cecum Lack of completion of the second and most essential process of intestinal rotation leads to the condition called non rotation of the bowel, in which the small intestine occupies the right portion of the abdomen, and the colon the left Inadequate mesenteric fixation characterizes such cases and they are prone to periodic attacks of pain occasioned by torsion of the gut upon an elongated and inadequately fixed mesentery Wakefield and Mayo call attention to the fact that the cat's intestine remains in the position of non rotation Gardner and Hart have recently collected 105 cases of bowel obstruction which had their origin in imperfect intestinal rotation Volvulus of the bowel is described under a special caption as is also *hernia of the intestine through mesenteric defects*

Treatment

The writings of Haymond and Dragstedt (1931), Gardner and Hart (1934) Jones and Morton (1938) Miller (1939) McIntosh and Donovan (1939) have helped to clarify the nature of obstruction attending anomalies of intestinal rotation These papers have served to indicate that the condition is by no means rare Ladd and Gross (1941) report 44 cases from The Children's Hospital in Boston alone In instances presenting volvulus detorsion must of course be done

The Writer's Operation for Non rotation

The matter of securing satisfactory mesenteric fixation in instances lacking normal attachment, is not so simple In instances presenting non-rotation of the bowel, the writer has in a few instances carried out the



Fig 136—Roentgen films of non rotation of the intestine before and after operation A The small intestine lies on the right side of the abdomen B The colon lies on the left C After performance of the type of operation shown in Fig 135 Loops of small intestine lie within the U loop of the colon D The position of the colon outlined by a barium enema

operative procedures depicted in Figure 135 An incision is made along the right lateral border of the small intestine and a similar incision just to the right of the right border of the unrotated colon, the colon is pulled over to the right an incision is made in the transverse meocolon and the small intestine is returned to its normal position Finally it becomes necessary to sever the lower ileum and to bring the very terminal segment

of the lower ileum forward from behind the cecum, reanastomosing the ileal segments in the normal position Latterly, the writer has closed the terminal ileum, employing this segment as a means of decompressing the colon during the early recovery period In this latter procedure, the proximal segment of the obliquely divided ileum is anastomosed, end to side to the ascending colon A distinct advantage of this latter procedure, over end to end anastomosis of the terminal ileum is that, no risk of compromising the blood supply of the terminal ileo colic segment is involved In order to free the terminal ileum adequately to pull it forward from be-



Fig 137—Recurrent and chronic obstruction due to congenital duodenal stenosis of extrinsic origin (Waugh Ladd compression syndrome) This boy K B Univ Hosp No 609772 aged 14 had been subject to frequent recurrent abdominal pain and vomiting A The x ray film before severance of bands compressing the duodenum B After the operation The boy has grown a great deal since operation and has no complaints

hind the cecum, it may be necessary to cut some of its mesentery Closing the terminal ileum and establishing intestinal continuity by end to side anastomosis with the cecum or ascending colon circumvents this potential source for trouble The results attending this type of correction have been very satisfactory The radiographic end result in a patient in whom this operation was done is shown in Figure 136

B EXTRINSIC DUODENAL STENOSIS

Compression of the retroperitoneal duodenum by abnormal bands is related probably to the final stage of rotation of the bowel—mesenteric fixation As was indicated above, extrinsic compression of the duodenum by abnormal bands may coexist with non rotation Extrinsic duodenal stenosis has been described in part already in Chapters XI and XVI The technique of dealing with the condition at operation is indicated in Figure 138 Unlike duodenal atresia which concerns newborn infants invariably, patients with extrinsic duodenal stenosis may come first for surgical relief during adolescence or even adulthood (Fig 137)

The writings of Ladd have helped materially to clarify the nature of

the obstruction and the necessary operative maneuvers directed at its relief A number of us, undoubtedly, performed duodeno jejuno tomy for the relief of this condition before becoming familiar with Ladd s writings on the subject Ladd has pointed out that, division of the adhesions causing the duodenal compression makes a direct attack upon the bowel itself unnecessary Rixford (1920) had indicated already that severance of adhesions about the duodenum might rectify the condition and reported

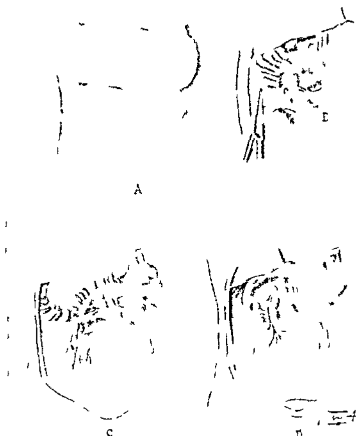


FIG 138—Ladd s operation for extrinsic duodenal stenosis due to compression bands (a) The dilated duodenum sketched from 137A (b) Division of the avascular colic and the cystico-colic ligaments to expose the duodenum (c) Cutting the duodenal compression bands (d) The course of the duodenum after severance of the bands

one such case in a child of 5 years And Waugh (1928) described the condition as an entity and reported several instances in which a procedure very similar to the Ladd operation of division of extrinsic adhesions compressing the duodenum had been done Ladd s experience with the operation is summarized in Chapter XI

C EXOMPHALOS (OMPHALOCELE UMBILICAL EVENTRATION)

In part, the difficulty of closing the abdomen, after excision of a large omphalocele may be circumvented by initial closure of the skin alone At a later date, when the muscles of the abdominal wall have been stretched out incident to replacement of the intestine in the peritoneal cavity, the deeper layers may be approximated Ladd and Gross report a number of two stage closures for the repair of this defect They found that the size of the sac was an important determinant in the mortality In sacs over 8 centimeters in diameter, the mortality was 85 per cent When the diameter of the sac was less than 8 centimeters, the mortality was only 25 per cent

D MECKEL S DIVERTICULUM

The persistence of the vitello intestinal duct in man is said to occur in almost 2 per cent of instances It arises from the free border of the ileum, usually within 20 to 100 centimeters from the cecum Kelynack found 12 instances of its occurrence among 1446 autopsies, an incidence of 1 in 80 or 0 8 per cent In no instance was death caused by its presence and no foreign bodies were contained in its lumen The average distance from the ileocecal valve was 34 5 inches (88 centimeters), the greatest distance was 50 5 inches (127 centimeters) and the shortest, 15 inches (38 centimeters) The average length was 2½ inches (6 3 centimeters) the longest was 6½ inches in length (16 5 centimeters) and the shortest was ½ inch (1 2 centimeters) in length In a collective report made to the Anatomical Society of Great Britain and Ireland in 1892, persistence of Meckel s diverticulum may persist as (1) complete pervious external fistula (2) sinus at the umbilicus (3) cyst of the umbilicus, (4) enterocystoma (5) fibrous cord from the ileum to the umbilicus or (6) the differentiated diverticular process from the bowel (Miller and Wallace) In turn the well developed diverticulum may have accompanying remnants of its blood supply, a cord like adhesive band which may go to the umbilicus or to the proximal mesentery of the ileum Evagination of the bowel with obstruction may occur through a persistent fistula at the umbilicus The more frequent varieties of bowel occlusion occurring through this agency are (1) simple or strangulating obstruction by a constricting band, (2) intussusception less commonly volvulus of the

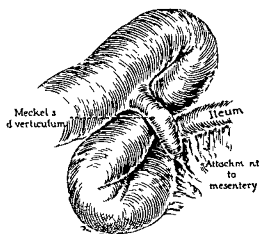


FIG 139—Intestinal obstruction due to Meckel s diverticulum a loop of ileum has been captivated beneath the diverticulum and an adhesive band which attaches it to the mesentery

diverticulum alone or including the adjacent ileum may occur In 326 cases of Meckel's diverticulum collected by Wellington, 212 were obstructed in 59 instances intussusception was present in 9 volvulus and in the remaining 144 the type of obstruction most commonly present was in the nature of an adhesive band The impaction of foreign bodies, such as gallstones (Hanke), in a Meckel's diverticulum has been noted, as well as the occurrence of obstruction through feces becoming impacted in it (Bettmann and Blum) Tuberculosis, enterocystomas pancreatic tissue, carcinoid tumors carcinoma and sarcoma have all been found in Meckel's diverticulum some of which conditions have caused bowel obstruction A partially duplicated ileum has occurred in association with a Meckel's diverticulum Two rather infrequent non obstructive surgical conditions of Meckel's diverticulum are (1) the occurrence of gastric glands in its wall with the occurrence of perforation or hemorrhage (Cobb) and (2) diverticulitis Waugh (1941) and his associates have reported instances recently in which strictures developed in the intestine opposite a Meckel's diverticulum due undoubtedly to a healed acid ulcer

Instances of giant Meckel's diverticula have been reported In this connection so called duplications of the intestinal canal should be mentioned Some of these are related to remnants of the vitello intestinal duct (Meckel's diverticulum) others are not Ladd and Gross have reported several instances of this sort In addition there are enterocystomas of the bowel wall or in immediate relation to the bowel wall having their origin in the adjacent mesentery The latter are frequently of lymphatic origin Some of the true enterocystomas of the gut wall represent, undoubtedly remnants of the vitello intestinal duct Rea (1940) described a case of enteric cyst in which contractions could be made out over the swelling during peristaltic rushes

The clinical features of bowel obstruction caused by Meckel's diverticulum participate in the general character of the particular variety of obstruction present and have already been discussed under other captions Buchanan claims to have made the diagnosis of bowel obstruction due to Meckel's diverticulum by a process of exclusion before operation Pfahler has twice detected the presence of Meckel's diverticulum on barium study of the small intestine In the compound entero enteric colonic intussusception of early childhood, the likelihood of a Meckel's diverticulum constituting the apex of the intussusception is great The writer has seen two such cases Montgomery states that the mortality of obstruction caused by Meckel's diverticulum approximates 50 per cent—an indication that in the majority of instances a late strangulating type of obstruction is present Obstruction due to Meckel's diverticulum is to be treated in accord with the guiding principles of the type of obstruction present, which most frequently is that of an adhesive type of mechanism or of invagination In the removal of the diverticulum care is to be taken not to narrow the bowel so that stricture will result Brown records the instance of a gangrenous diverticulum in which he exteriorized the intestinal segment concerned and applied a clamp to its base A temporary fistula formed which closed spontaneously

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CHAPTER XXIII

INHIBITION ILEUS (PARALYTIC)

(*Adynamic Obstruction*)

A PATHOGENESIS

THIS TYPE of obstruction is most often seen in peritonitis Its occurrence in mild grade following intra abdominal operations of practically every sort is well known Incident to each operative interference in the peritoneal cavity, a moderate paretic condition of the bowel obtains in which distension and difficulty in expelling gas occurs As the paresis begins to be recovered from dilated loops contract down upon their gaseous and fluid contents and give rise to "gas pains" Reflex inhibition ileus is observed following strangulation of the omentum, in renal attacks not uncommonly (Eisendrath) and less frequently in gallbladder colic, following torsion of an ovarian cyst and strangulation of the spermatic cord a reflex dilatation of the intestine with markedly impaired motor power may obtain Following blunt trauma of the abdomen prolonged ether anesthesia (Frey) or even accompanying fractured ribs paralytic ileus may be seen Following thoracoplasty and especially after excision of lower ribs on the left side inhibitive ileus may after injuries of the spinal column and following hyperextension in a plaster of Paris body cast, intestinal distension is not infrequent Olivecrona has studied the anatomical basis for distensions accompanying trauma and states that inhibitory phenomena are responsible Embolism and thrombosis of the mesenteric vessel not infrequently give rise to similar distension of the intestine Retroperitoneal infection, hemorrhage or tumors are occasionally causes of paralytic ileus In the course of some infectious fevers especially meningitis, pneumonia and septic conditions in general meteorism of severe grade may be seen

After injury or damage to the central nervous system a varying degree of paralytic ileus may follow as also occurs following injuries of the spinal cord Joyce relates several instances where the abdomen has been opened for obstruction caused by retroperitoneal hematomas and Sohn refers to two cases of spontaneous perirenal hemorrhage which gave rise to symptoms of intestinal obstruction for which laparotomy was performed in one instance Demel has demonstrated in animals that, the presence of blood in the retroperitoneal space, especially in the vicinity of the splanchnic nerves gives rise to intestinal meteorism

It has generally been believed in the distension of the intestine associated with peritonitis and some of the other conditions mentioned that an actual paralysis of the motor power of the intestine exists Hotz, however demonstrated a number of years ago that loops of intestinal musculature from animals suffering from peritonitis exhibited a fairly normal contractile power and the reaction to stimulation with drugs was normal This

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periods of time, whether by occlusion of the lumen or inhibitive forces, which interfere with the transport problem of the bowel In inhibitive ileus as in mechanical obstructions, in early cases, the distension is largely gaseous late cases of both varieties exhibit considerable fluid in the bowel It would appear, therefore, that distension in inhibitive ileus threatens the viability of the bowel wall, just as it does in mechanical obstructions Bayliss and Starling (1894) pointed out many years ago that the capillaries of the intestinal mucosa are more permeable to protein than are other capillary blood vessels (See Systemic Effects of Distension, pages 41 44) When long reaches of bowel are distended, as occurs invariably in inhibitive (paralytic) types of ileus, the loss of plasma is an additional factor to be considered From the peritoneal cavity such transudations of fluid would be absorbed probably, until its protein content, with increasing injury to the intestinal wall, approximated that of plasma The influence of great distensions in segregating blood and plasma in the lower extremities has been described already (page 41)

C CLINICAL FEATURES

Extreme meteorism dominates the picture in paralytic ileus Whereas, in mechanical obstruction, the intestine above the point of occlusion becomes gradually distended, in paralytic ileus, quick dilatation of the entire intestinal tract occurs giving rise frequently to enormous clinical distension The source of this gas is also largely swallowed air (Hibbard 1936) During cystoscopic examinations and pyelography one not uncommonly is afforded an opportunity of seeing how rapidly air will negotiate the entire length of the intestinal canal Incident to the distension, considerable respiratory difficulty is often present The breathing is largely costal in character, superficial and rapid the pulse is frequently hurried and small Tenderness over the abdomen is usually present very little or no pain may be complained of On auscultation, the abdomen is relatively silent, only feeble noises being audible The heart sounds and even the breath sounds may be heard over the abdomen in the presence of considerable fluid in the bowel and in the peritoneal cavity—the explanation being that fluid is a good resonator (Peters) No gurgling or splashing sounds are present The patient frequently complains of severe thirst but regurgitates all fluid ingested The urinary output is scant and if fluids are forced by the subcutaneous or intravenous route edema frequently obtains Despite the obviously dangerous condition of the patient he frequently has no conception of the gravity of his illness Euphoria is commonly observed Enemas may be partially expelled with a return of fecal matter and small amounts of gas, occasionally no return is obtained A scout film of the abdomen usually shows gaseous distension of the entire intestine with layering of fluid between the coils There are seen now and then to be certain instances of inhibitory ileus in which only a few coils of intestine are distended Careful integration of clinical and roentgenologic findings, therefore must always be made The absence or presence of *intestinal colic* is an important determinant in the diagnosis Pain is not a usual complaint but occasional intestinal gurgling may be heard

observation lends tenable support to the belief that, the extrinsic nerves of the intestine play an important role in the motor inhibitions in peritonitis The vagus *is the motor nerve of the greater portion of the intestine* and the influence of the sympathetic is inhibitory to the bowel but motor to the sphincters It has been shown by shunting out the influence of the sympathetic, by division of the splanchnics or blocking them with splanchnic or spinal anesthesia, that the paretic intestine of paralytic ileus can be made to contract (Wagner, Ochsner and associates, and others)

Paralytic ileus is therefore an ill chosen name for the meteorism and motor inactivity observed in the conditions enumerated above The intestine is not paralyzed, its activity is inhibited and restrained by an *overactive sympathetic influence In chemical* iodine peritonitis, Frey observed the intestinal activity through a celluloid window and found that, dilated and contracted segments responded similarly to stimulation with choline given subcutaneously In the intestines distended with gas for several hours, Hotz found that, the rhythmic contractions of the segment ceased The gaseous distension of the loop and not the toxins of peritonitis, Hotz concluded were responsible for the disappearance of intestinal contractions Distension of the intestine impairs absorption, and the gas in the intestine, which is normally carried away as fast as it is formed, continues to accumulate and a vicious circle ensues (Alvarez, Usadel)

B PATHOLOGY

The entire intestine may be dilated in paralytic ileus The degree of intestinal dilatation may vary considerably There are usually large collections of both fluid and gas throughout the entire intestine The bowel wall is very much thinned out and is frequently somewhat dusky in appearance due to the venous stasis occasioned by the dilatation of the bowel and pressure on the mesenteric veins returning from over the surface of the bowel *In peritonitis, the serous surfaces of the visceral peritoneum partake* of the characters of the inflamed peritoneum in general, presenting a reddish angry surface with frequently a disappearance of the normal sheen and luster of the intestine The collection of exudate in the peritoneal cavity may be serous, fibrinous, or fibrinoplastic in character In cases of paralytic ileus of a reflex nature, no fluid is ordinarily present in the peritoneal cavity and the parietal serous surfaces appear normal Despite the enormous distension that may be seen in paralytic ileus, perforation and gangrene of the intestine are rare occurrences

It is not unlikely that the end effects of distension in inhibitive (paralytic) ileus are not unlike those of mechanical obstruction upon the bowel wall That is sustained intraluminal pressure whether occasioned by a mechanical obstruction or paresis of the bowel wall subjects the bowel wall to the hazards of anoxemia Inasmuch as peristaltic contractions are not pyramided on the sustained intraluminal pressure in the latter condition the injury to the bowel wall would not be as prominent Further there have been very few recordings of intraluminal pressure in a dilated paretic bowel However, it is likely that, the end effects are largely the same in loops of bowel, becoming dilated to the same extent over similar

likelihood of quicker decompression of the distended intestine When the distension concerns the colon essentially, the tidal irrigation as suggested by Pratt may be helpful Rectal irrigation in peritonitis is distinctly out of place Feces and the colonic flexures, moreover, constitute serious obstacles to effectual operation of rectal siphonage The necessity for enterostomy has been largely done away with by the more effectual and less hazardous practice of gastro duodenal siphonage

Occasionally, within a few minutes following aspiration of large quantities of gas and fluid from the stomach and upper reaches of the small intestine, a cyanotic and apparently moribund patient may present a wholly changed appearance In the instance of an old man with a urinary tract infection 7000 cubic centimeters, largely gas, was aspirated in a few minutes with startling immediate results and eventual recovery, in a patient who e status was extremely precarious because of a ruptured spleen the removal of 4500 cubic centimeters of gas and fluid by gastric siphonage revived what appeared to be a dying man These rather extreme cases attest the significance of the mechanical effects of distension

The suggestion of Handley that an ileo colostomy be done in instances of paralytic ileus would appear to have no justification He alleges that an ' ileus duplex ' obtains in paralytic obstructions, by which designation he implies that there is simultaneous mechanical obstruction to the small intestine and inhibitory to the colon No proof has been brought forward to indicate that this is the state of affairs in paralytic ileus All evidence would point to the contrary, viz that the small and large bowel participate in the same inhibitory process the extent of which may vary considerably It would not appear that the operation which Handley has recommended has any place in the treatment of paralytic ileus Cases which one may with justice call "ileus duplex" or multiple obstructions in the experience of the writer, have been mechanical in nature The most frequent association has been adhesive obstruction of the small intestine and carcinoma of the colon When a carcinoma or granulomatous process in the colon ulcerates into the small intestine and establishes an artificial anastomosis obstructive features common to both small and large intestine may be observed Finsterer Block and Schlaepfer have reported instances of multiple obstruction

For protracted inhibitory ileus not due to peritonitis and refractory to treatment by suction spinal anesthesia may prove of value in some instances It has been demonstrated experimentally, when the sympathetic inhibition to the intestine is released by cutting the splanchnics by splanchnic or spinal anesthesia that evacuation of the intestine may be obtained Arai Markowitz and Campbell and Ochsner and his associates have produced chemical peritonitis by the intraperitoneal injection of iodine following which the motility of the intestine for the transport of barium practically ceased Following the administration of spinal anesthesia intestinal contractions would again function and evacuations were obtained David and Loring however, found splanchnic anesthesia to be effectual for only brief periods

A considerable number of clinical papers have accrued to attest the

In those instances of reflex ileus due to renal colic, *torsion of the or*tum, or the like, subsidence of the primary disorder arrests the prog of the inhibition ileus and the symptoms quickly subside In paral ileus due to peritonitis, however, *delirium and coma are usually supe*posed on the picture described and the end is often fatal

Here might be mentioned a type of paralytic or inhibition ileus scribed by *Brunzel (1918) to which he gave the name of "fermenta* ileus " His report concerned 2 cases who exhibited signs of intestinal struction of a paralytic character following the ingestion of raw beans ' *and Brizke have since reported several such cases after the eating of* oats Some of these latter have, however, been actual cases of impac in the bowel

There are occasions in which differential diagnosis between mechani spastic and inhibitive (paralytic) ileus may be difficult or impossibl make The consideration which causes the clinician the greatest conc is whether a strangulating mechanical obstruction may be present writer has encountered this dilemma many times, once in a severe p operative wound infection which gave very few local signs

D TREATMENT

The treatment of paralytic ileus presents two extreme difficulties, to cope successfully with the cause and (2) the treatment of the inact bowel In inhibition ileus occasioned by retroperitoneal collections of e date, the treatment indicated is adequate drainage, and in the prese of hemorrhage, the staunching of the source of blood loss Follow trauma, the ileus though primarily of severe grade, usually responds conservative measures of treatment Following torsion of the testis ovary, the paresis of the intestine usually comes to a standstill after t active process has reached its peak or following proper surgical treatme

Considerable has been written concerning the value of various co servative measures of treatment Hot stupes to the abdomen, atrop pituitary extract, pilocarpine, physostigmine, and choline have all be advocated in the treatment of the distension observed during the cou of the ileus Though enemas may give temporary relief and may perm of the evacuation of some gas, they are usually of no great value and a to be avoided in the presence of intraperitoneal infection In paralyt ileus accompanying peritonitis, the value of enterostomy has been extoll by a number of authors Prominent among these are Krogius, Heidenha Melchior, Hofmeister, and Kausch The observation of most surgeo has been that catheter drainage of the intestine in paralytic ileus is on of very limited value because only a short segment on either side of t catheter is evacuated by the tube Heidenhain and others have recom mended employment of multiple enterostomies

The agent of most value in the treatment of paralytic ileus is the ap plication of suction to an inlying duodenal tube With the employment c this expedient the stomach and upper jejunum will usually be emptie immediately Employment of the Miller-Abbott tube has enhanced th

tension, no patient with paralytic ileus has been subjected to operation for its relief Yet, the more rapid deflation attending surgical relief of a persistent gaseous distension would appear to warrant its occasional employment in those instances which respond slowly or remain refractory to an adequate trial with suction

Smith (1941) has reported from this clinic two instances, in which plastic masses gave rise to intestinal obstruction The patients were treated with the Kettering hypertherm unit, suction being employed to control distension Prior to employment of suction, such patients were operated upon, enterostomy or colostomy being performed usually A not infrequent sequel was spreading peritonitis with more distension necessitating another operative procedure The writer once did 3 successive enterostomies for such a patient, she dying ultimately of peritonitis—the peritoneal infection gaining a little more headway with each operative endeavor Suction has changed all this A patient who can live for weeks with some distension has a good chance of recovery, if the distension can be dealt with satisfactorily by non operative means The Miller Abbott tube with intermittent suction and feeding combined with proper use of the Kettering hypertherm and the sulfonamides affords a number of such patients the opportunity of surviving peritonitis granted that the organism can hold the infection in check

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value of spinal anesthesia in paralytic ileus Duval has collected 400 cases of obstruction of various sorts from the French literature in which spinal anesthesia has been employed with varying success Wagner was the first, in 1912, to apply the experimental knowledge of the release of splanchnic inhibition in cases of paralytic ileus He introduced para vertebral splanchnic anesthesia in a number of cases and reported eight cases in which there was marked retrogression of the meteorism following its employment Novikov (1940) has suggested and employed right or left lumbar novocaine block in the treatment of inhibitive ileus He finds that its use makes operation unnecessary in patients with ileus, in which the obstruction is not mechanical in origin He finds such novocaine blocks helpful also in instances of spastic ileus Novikov recommends the injection of 50 to 100 cc of a ¼ per cent solution of novocaine The investigations of Shumacher (1941) on novocaine toxicity and absorption deserve study by everyone interested in this aspect of the problem

Another agent of value in certain cases in inhibition ileus is the intravenous injection of hypertonic solution of saline Hotz pointed out the stimulating effect of intravenous injections of saline solution upon intestinal contractions and Hughson and Scarff first directed attention to the clinical value of this drug in increasing the motile power of a paretic intestine One sixth to one third of a gram per kilo body weight may safely be injected Seventy five to one hundred cubic centimeters of a 15 per cent solution of sodium chloride is the usual dose for a person weighing 70 kilos (154 pounds) and is often very effectual

In the main the writer inclines to the passive treatment of inhibitive ileus by suction reserving the employment of active stimulating agents for instances in which such additional therapy is necessary Use of the long balloon tipped tube (Miller-Abbott) is advisable when an inlying duodenal tube fails to relieve the distension Hotz (1909) indicated many years ago that, such loops had not lost their contractility Decompression, however, may be even more difficult than in a mechanical obstruction presenting a similar grade of distension Golden and associates (1940) emphasize that in many instances despite entry of the balloon tipped tube into the duodenum, progress of the tube down the intestine is unusually slow—5 to 7 days and longer being required occasionally to effect decompression The majority of instances of paralytic ileus can be managed without recourse to drugs such as pituitary extract, prostigmine eserin, or hypertonic intravenous saline solutions Despite the vigorous application of suction to inlying duodenal tubes, as a routine measure in the treatment of established paralytic ileus, an occasional case may be observed in which recourse will have to be had to operation to achieve adequate decompression Instances of paralytic ileus not due to peritonitis not uncommonly respond as favorably to surgical decompression as do instances of mechanical obstruction (Hunt, Bartlett) The segment which has been most greatly and persistently dilated as determined by x ray examinations should be tapped by enterostomy or colostomy as outlined under the caption of operations Over an eleven year interval during which time suction has been widely employed at the University of Minnesota Hospitals in the treatment of dis-

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Chapter XXIV

SPASTIC ILEUS

(Dynamic Obstruction)

A PATHOGENESIS

This disease was first described as an entity by J B Murphy in 1896 His description concerned a painter who was taken ill with abdominal cramps of a spasmodic character, vomiting and an inability to move the bowels The abdomen was greatly distended and all efforts to move the bowels by cathartics and intestinal irrigations proved futile The patient had previously had attacks of lead colic At operation Murphy found a loop of small intestine about eight inches in length that was contracted and stiff as a rope of similar size, the intestinal coil being about three-eighths of an inch in diameter (Fig 140) The intestine above it was somewhat dilated and measured two and one half inches in diameter and was distended with gas and fluid feces The intestine below was empty soft and pliable After ten minutes' exposure to the air spasm at the proximal end substantially diminished and the contracted segment began to dilate After twenty minutes of observation, this contracted coil had expanded about one inch in diameter and was returned to the abdomen

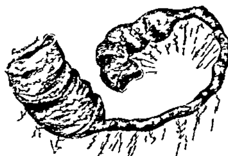


Fig 140—J B Murphy's case of spastic ileum of the small intestine illustrating the contraction of the bowel (J.A.M.A 26 15 1896)

Two years later, Heidenhain reported three similar cases and since that time the entity of spastic ileus has become fairly well known In 1924 Korte reported 28 cases that had come under his observation Zimmerman has recently collected 157 cases of this type The majority of cases were in patients in the mid span of life, 3 were under one year The writer has observed spastic ileus in a patient past 80 years

Fromme classifies the causes of spastic obstruction as follows

(1) External due to injuries
(2) Factors from within the bowel, such as foreign bodies, worms, ulcers and irritating intestinal content
(3) Neurasthenia and hysteria
(4) Unknown

Attention has already been called to the fact that spasm may be an initial step in intussusception and that it may play an important role in gallstone obstruction when the size of the gallstone is not of itself large enough to occlude the lumen of the bowel Its role in producing obstruction

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cently this manifestation of spastic ileus The majority of these patients are women who, in the absence of symptoms of obstruction, are readily recognized as neurotics who e chief complaint concerns the bowel Many have trouble with constipation others with gas and pain at times such patients may be subject to diarrhea many have been repeatedly subjected to operation under the diagnosis of mechanical obstruction of adhesive origin Some of the e patients may present at times, as well, a picture which re embles paralytic ileus The effect in either event may be the same viz dilatation of the entire bowel Morse (1936) has described ob erving sudden reversals from hypertonicity to hypotonicity of the colonic musculature and vice versa with the aid of the barium enema When the patient is afflicted with spastic ileus he has gas pains and *intestinal colic* can be demonstrated, in the other instance he complains only of distension and the abdomen is silent The writer has thrice observed palpable peristalsis in spastic ileus the gut being felt through the layers of the abdominal wall—a finding which obtains regularly when acute intestinal obstruction attends stricture of the gut (ee Fig 21)



Fig 141—Enormous distension of the colon in spastic ileus This patient had been operated upon many times for adhesive obstruction The greatest difficulty lies in differentiating the intestinal colic and distension of this condition from that due to an organic obstruction of the pelvic colon

D DIAGNOSIS

There is no way in which one can wholly be certain that such an obstruction pre enting all the clinical features of mechanical occlusion is merely due to spasm without recourse to operation The antecedent history is frequently helpful A history of bowel di tress over a long period of time is suggestive The patient who e symptoms of obstruction begin acutely with an attack of renal colic, after injury or intraperitoneal hemorrhage can usually be correctly identified without much difficulty Spastic ileus involving the colon may be confu ed with mechanical obstruction of the colon due to carcinoma It would appear that the mere administration of a barium enema would erve to differentiate these Unfortunately however such is not always the case Some of these difficulties have already been described (pages 93 and 105) Could the roentgenologist be as certain of his findings with the barium enema in the presence of great di tension as he is when di tension is ab ent colonic pa tic ileus would occasion no trouble in differentiation The employment of spinal anesthesia is sometimes helpful in that with relea e of the sympathetic nervous influence to the bowel, spontaneous evacuation ensues (Scott and Morton)

in the presence of worms in the intestine has already been described (Chap 14) Korte described also spastic ileus concomitant with an attack of renal colic and refers to its occurrence in the presence of uremia In the course of influenza and other infectious fevers, the occurrence of spastic ileus has several times been noted Steindl has recently contended that degenerative changes in the medulla oblongata may precipitate intestinal spasm Occasionally a patient who has been observed through several attacks of spastic ileus of unknown origin will finally present a reasonable cause The writer has observed this occurrence in two patients one of whom subsequently showed unmistakable evidence of tuberculous peritonitis, the other, of a kidney infection It is possible that instances of perforation of the colon in new borns (so called meconium ileus) as well as instances of so called simple ulcer of the colon (Barron, Wilkie), are due to spasm of the colon The role of intestinal spasm in Hirschsprung's disease has been described (chapter XV)

B PATHOLOGY

The appearance of the spastic loop may be that noted by Murphy in lead colic There may be a single collapsed area of small bowel or there may be numerous such areas Korte and others have observed instances in which the spasm did not disappear in narcosis, it has also been said to persist even after death for a short time These occurrences suggest that the intrinsic nerve plexuses in the bowel are largely responsible for the spasm Segments of the colon or the small intestine may be concerned in the process In the collapsed segments there may be ring like constrictions Korte states that four cases of enterospasm under his observation came to necropsy There was no necrosis of the mucosa and the bowel wall appeared normal The bowel dilates above the spastic area and exhibits gaseous fluid accumulation No perforations were noted in fatal instances reported by Korte Amberger however, reports such an occurrence It is not unlikely that instances of so called meconium ileus may have their origin in such an agency Simple ulcer of the colon described by Barron (1928), Wilkie and Barlow (1941) may have its origin through the agency of tension penetration or perforation caused by mechanical spasm in the pelvic colon

C CLINICAL FEATURES

The clinical picture simulates very closely that of mechanical obstruction *Intestinal colic* is invariably present If the obstruction concerns the small intestine, nausea and vomiting are the rule In instances where the obstructive element has long been present, coils of bowel may be seen and felt through the abdominal wall, lending the impression that a stricture of the bowel is present The writer has twice encountered this occurrence in the small intestine In one of these the distension stopped abruptly at the junction with the cecum—an occurrence which would suggest that the neuromuscular mechanism of the ileocecal sphincter was probably at fault In the experience of the writer the most frequently observed type of spastic ileus concerns the colon (Fig 141) The writer described several such cases in 1931 Colp (1941) has emphasized re-

measures or by operation when necessary, they are subject to frequent recurrences The writer has observed several patients who have had multiple operations for obstruction, in whom the items of a low basal metabolic rate achlorhydria and vomiting without much pain suggest a neurotic state The surgeon must be wary not to start such patients on a course of multiple operations Some of these patients probably have a condition akin to that of true megacolon and it is not unlikely that relief may be obtained for some of them by the more adequate sympathectomy of Royle or Adson Antispasmodics such as atropin and amyl nitrate are to be tried, but in the main, have not proved very effectual Heiman and Cohen and Cowie are enthusiastic over the value of atropin in the relief of enterospasm of children Cowie states that he has given as much as 1/30 grain (2 mg) of atropin sulphate to obtain relief Recently it has been suggested that benzedrine may effectively allay intestinal spasm (Myerson and Ritov), Desiccated thyroid and Vitamin B_1 are often helpful (See discussion on page 355 also)

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E TREATMENT

In those instances in which distension is great, re ort must be had to operation Fatal instances have been reported owing to failure to decompress the distended bowel (Amberger, Korte, Steigmann and Singer) In instances where the diagnosis can be made and distension is not threatening, operation is of no avail Such cases will usually respond favorably to conservative treatment with suction applied to an inlying duodenal tube and hot applications to the abdomen Use of the Miller-Abbott tube is helpful to achieve decompression and to permit feeding, as long as the spastic element continues Such a favorable termination is almost invariable in the acute cases of spastic ileus accompanying injury or infection Some of these have distension of both the small intestine and colon All that operation has to offer a patient with spastic obstruction is relief from the distension Spinal anesthesia sometimes succeeds in *securing a spontaneous evacuation in instances of colonic spastic ileus* On one occasion, the writer inserted a sigmoidoscope into the lower bowel for a distance of 20 centimeters and then inverted the patient in the hope that the gas would be released from the greatly distended colon—but without success

When spastic ileus of the small intestine demands operation enterostomy should be done, for the colonic case colostomy as described on page 199 should be done During convalescence after decompression had been achieved by colostomy in a patient with spastic ileus, whose colon was enormously distended, the writer subsequently did the sympathetic neurectomy of Rankin and Learmonth, but without improving the patient's condition The more complete sympathectomy of Royle or Adson might have been more successful Flothow and others report good results in some patients with obturate constipation who present some similar features Scott's suggestion of ascertaining whether spinal anesthesia will afford relief before sympathectomy is done, is a good one The writer has, however, noted in mechanical obstructions of the small bowel that the *diameter of the obstructed coils is also diminished by spinal anesthesia* X ray films taken immediately before and after the administration of spinal anesthesia in mechanical obstructions of the small bowel, usually reveal a diminution of calibre on the second film

For this patient Miss R, University Hospital #55787, aged 23, referred to above for whom the partial sympathetic neurectomy was performed, I subsequently divided the terminal ileum (Dec 8, 1930), bringing the distal end as a safety vent to the skin, the proximal end being anastomosed end to side to the transverse colon It was my impression that a catheter could be passed during obstructive attacks into the cecum to relieve distension—an idea which Spivack (1932) put to good use in suggesting employment of the cecum and ascending colon as a blind pouch in patients with a permanent colostomy Another surgeon did not think well of my idea and closed the safety vent which I had made in the patient described above with recurrent spastic ileus of the colon

The most unfortunate thing about these patients is that, whereas the acute attack may be dealt with satisfactorily, either by conservative

measures or by operation when necessary, they are subject to frequent recurrences The writer has observed several patients who have had multiple operations for obstruction in whom the items of a low basal metabolic rate, achlorhydria and vomiting without much pain suggest a neurotic state The surgeon must be wary not to start such patients on a course of multiple operations Some of these patients probably have a condition akin to that of true megacolon and it is not unlikely that relief may be obtained for some of them by the more adequate sympathectomy of Royle or Adson Antispasmodics such as atropin and amyl nitrate are to be tried, but in the main, have not proved very effectual Heiman and Cohen and Cowie are enthusiastic over the value of atropin in the relief of enterospasm of children Cowie states that he has given as much as 1/30 grain (2 mg) of atropin sulphate to obtain relief Recently it has been suggested that benzedrine may effectively allay intestinal spasm (Myerson and Ritov) Desiccated thyroid and Vitamin B_1 are often helpful (See discussion on page 355 also)

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Chapter XXV

INTESTINAL OBSTRUCTION DUE TO VASCULAR CAUSES, MESENTERIC THROMBOSIS AND EMBOLISM

A PATHOGENESIS

In 1913 Trotter reported seven new cases of mesenteric thrombosis and embolism and collected in monographic form a total of 360 cases from the literature He states that arterial occlusion contributed 60 per cent of the total and thrombosis of the mesenteric veins the remaining 40 per cent In a few smaller series, venous thrombosis has been observed to occur more frequently than thrombosis and embolism of the arteries

The superior mesenteric artery is more frequently concerned in embolism than is the inferior, partially because of its earlier exit from the aorta but largely because of its more direct continuation from the abdominal aorta Embolism of the inferior mesenteric artery may obtain and infarction of the bowel fail to occur, significant of the freer anastomosis which occurs between the end vessels of the systemic arteries and the inferior mesenteric branches

Vegetations on the valves of the left side of the heart are the usual etiologic agents in embolism of the mesenteric arteries Ginsberg observed embolism to occur 85 times in 250 cases of endocarditis and the superior mesenteric artery was involved in three instances Sperling, out of 300 cases of endocarditis found embolism in 84 in some organ, including five with embolism in the liver and intestine Embolism of both mesenteric arteries is a very rare condition, Trotter refers to three such cases

Embolism of the mesenteric arteries is more frequent than thrombosis of the arteries Of 187 cases of mesenteric arterial occlusions referred to by Trotter embolism was responsible for 128 In a recent review of 36 postmortem cases of mesenteric vascular occlusion, Larson found arterial thrombosis more frequent than arterial embolism

Mesenteric venous thrombosis is usually associated with infection in organs or viscera that are tributaries to the portal vein Appendicitis portal infections, and strangulation of external hernias are frequent precursors of the occurrence

Thrombosis or embolism of the mesenteric vessels very rarely affect children adults between the ages of 30 and 70 are more likely to be attacked In Trotter's series males were affected more often—62 per cent as compared to 38 per cent for women

Occasionally following crushing injuries as when an automobile runs over the abdomen, a tear in the mesentery gives rise to a hematoma which deprives the intestine of its source of blood supply (Cave) Most of these are however, associated with injuries or tears in the bowel itself Inadvertent ligation of the midcolic artery in gastric resection has caused gangrene of the transverse colon

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diarrhea is more frequently observed Shock is generally manifest and the pulse is frequently rapid and irregular In mesenteric thrombosis, the explanation of the shock is apparent in the blood loss occasioned by an extensive venous infarction The temperature is normal or subnormal but occasionally there is fever even at an early stage Distension of the abdomen is progressive though not extreme An abdominal tumor was observed in about 5 6 per cent of the cases of intestinal infarction reported by Trotter Meyer reported the occurrence of melena in 14 per cent of 92 cases of mesenteric vascular occlusion Visible peristalsis was noted in only 4 out of 360 cases collected by Trotter Intestinal noises may be heard on auscultation of the abdomen, but *intestinal colic* is rarely a prominent feature of the acute occlusion Distension of both small and large bowel are usual on a roentgenogram Not uncommonly, the pain which is frequently agonizing in the beginning may show temporary

TABLE XLIV —SITE OF MESENTERIC VASCULAR OCCLUSION IN SIXTY CASES (WHITAKER & PEMBERTON) JOUR A M A 111 21 24 JULY 2 1938

Type of Occlusion and Vessels Occluded		Cases
Arterial occlusion		19
Superior mesenteric	18	
Combined superior and inferior mesenteric	1	
Venous occlusion		27
Superior mesenteric	25	
Inferior mesenteric	1	
Combined superior and inferior mesenteric	1	
Combined arterial and venous occlusion		14

diminution of intensity though the other symptoms continue usually unabated until death The infarction of a portion of the intestine is frequently complicated by peritonitis and its sequelae Distension may be absent altogether

D DIFFERENTIAL DIAGNOSIS

Mesenteric thrombosis and embolism are rarely recognized preoperatively A correct pre operative diagnosis was made in only 13 of the 360 cases collected by Trotter My associate Dr Lyle Hay, diagnosed, preoperatively, the presence of mesenteric thrombosis in a patient of 75 Mrs H H University Hospital #713329, and excised successfully a large portion of the small intestine by the closed method Intussusception frequently gives symptoms of a similar sort, but the majority of patients suffering from this disease are young, whereas in infarction, the majority have attained middle life The presence of an abdominal tumor is frequent in intussusception and rare in vascular occlusion Intermittent colicky attacks of pain characterize intussusception, whereas in vascular occlusion the pain is more continuous in character

Previous existence of a probable source for an embolus or adequate cause of mesenteric venous thrombosis should be present before the preoperative diagnosis of vascular occlusion can be entertained Acute pancreatitis or subacute perforation of a viscus that gives rise to signs of peritoneal irritation may lead to confusion The important thing to recognize is that a serious surgical lesion is present that demands opening of the abdomen

B PATHOLOGY

Serious damage to the intestine takes place in a large majority of cases after closure of any but a small branch of the superior mesenteric artery Closure of the inferior mesenteric artery is not always followed by intestinal infarction Out of 60 cases showing embolism of the trunk of the superior mesenteric artery, hemorrhagic infarction followed in 45 cases Edema, discoloration, gangrene, and perforation are the sequence of events unless the *infarcted segment is excised Distension of the in*

TABLE XLIII—THE SOURCE OF THE MESENTERIC VASCULAR OCCLUSION (WHITAKER & PEMBERTON) JOUR A M A 111 2124 JULY 2 1938

Source or Cause	Artery	Vein	Combined Artery and Vein	Total
Cardiac disease	9	1	5	15
Splenectomy for splenic anemia		8		8
Arteriosclerosis	5	1	2	8
Hepatic disease		6	1	7
Acute abdominal infections		6	1	7
Postoperative abdominal operation	3		2	5
Unknown	1	3		4
Other cases	1	2	3	6
Total	19	27	14	60

volved segment with the accumulation of bloody fluid in the peritoneal cavity as well as within the segment is the rule The demarcation of the involved intestine from the normal is usually sharp, though in some instances the healthy and diseased intestines are poorly defined

When obliteration of the mesenteric arteries occurs slowly, intestinal infarction may not result Chiene has placed on record the instance of a *female aged 65 years whose body was dissected in the anatomical labora*tories at Edinburgh The abdominal aorta was completely occluded by an aneurysm that extended as far down as the bifurcation The branches of the mesenteric arteries were filled by injection through the superior hemorrhoidal, which artery was as large as the femoral

C CLINICAL FEATURES

It is an interesting fact that many cases of mesenteric vascular occlusion run a fairly mild course, more than a week elapsing frequently before the existence of a serious lesion is suspected Jackson, Porter, and Quinby found out of 121 cases reported by them in 1904, that the percentage *of cases running a course of more than 8 days was about the same as* those running a course of less than 8 days The vascular occlusion in these relatively long cases is probably incomplete and progresses slowly until the *bowel finally becomes non-viable Trotter emphasizes the fact* that only a small percentage exhibit prominently the phenomena of mechanical obstruction of the bowel Distension may be absent

The usual manifestations of the disease are the *sudden onset of severe* acute abdominal pain, vomiting and diarrhea The stools and vomitus occasionally contain blood, constipation may be a prominent feature but

diarrhea is more frequently observed Shock is generally manifest and the pulse is frequently rapid and irregular In mesenteric thrombosis, the explanation of the shock is apparent in the blood loss occasioned by an extensive venous infarction The temperature is normal or subnormal but occasionally there is fever even at an early stage Distension of the abdomen is progressive though not extreme An abdominal tumor was observed in about 5 6 per cent of the cases of intestinal infarction reported by Trotter Meyer reported the occurrence of melena in 14 per cent of 92 cases of mesenteric vascular occlusion Visible peristalsis was noted in only 4 out of 360 cases collected by Trotter Intestinal noises may be heard on auscultation of the abdomen, but *intestinal colic* is rarely a prominent feature of the acute occlusion Distension of both small and large bowel are usual on a roentgenogram Not uncommonly the pain which is frequently agonizing in the beginning may show temporary

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TREATMENT

Early operation and excision of the involved segment of the intestine is indicated. There are a number of *reports in the literature of instances* in which the abdomen was merely opened and the entire small intestine found to be cyanosed—the patients having recovered without further operative procedure. In such instances *undoubtedly the vascular occlusion* was incomplete and recovery ensued. Ochsner states that he has observed this *occurrence in alcoholism*.

Deaver, Jopson, and Laws have each reported instances of this character, and Klein refers to 8 other patients reported in the literature where spontaneous cure obtained without the reliable corroborative confirmation supplied by exploratory *laparotomy*.



FIG 142.—Exteriorization in continuity of bowel of questioned viability. This *patient aged 68 presented findings of* intestinal colic with rebound tenderness suggesting the presence of a strangulating obstruction. At *operation a single coil* of mid small intestine was found to be discolored. It was quite free and exhibited no effects of pressure by an adhesive band from which it might possibly have escaped. A local segmental arterial or venous thrombosis therefore would appear to have been responsible for discoloration of this coil. Because of its doubtful viability it was exteriorized; seven days later when its viability was certain it was returned to the peritoneal cavity and the patient has remained well. Primary resection is probably a better operation. Should the bowel prove non viable the procedure *illustrated here would result in* complete external fistula—an undesirable complication.

The first successful operation for intestinal infarction was done by Elliot in 1895. The mortality of operation is admittedly high because *of the nature of the disease*. With early recognition in cases in which only a portion of the intestine is involved, a marked reduction in the present high mortality of the disease *should* obtain. *In the* 47 cases subjected to operation quoted by Jackson, Porter and Quinby, there were 4 recoveries. Klein states that up to 1921, 24 cases had been dealt with successfully by operation. In 1931, Meyer stated that 92 recorded operations for mesenteric vascular occlusion were to be found in the literature. In this group alone, there were 39 recoveries. Douglas reported 11 cases of mesenteric vascular occlusion from the records of St Luke's Hospital in New York. Four of the group recovered.

Intestine damaged beyond recovery of viability must be excised. Primary excision followed by a lateral *anastomosis* is the operation of choice when *feasible*. In dealing with a very ill patient, Elliot exteriorized the gangrenous small intestine and later reestab-

lished the continuity of the bowel After the method of McKinnon and Wilkie, the intestinal discharges from the proximal loop may be collected and poured into the distal loop If the bowel is doubtfully viable, it may be exteriorized (Fig 142) The closed anastomosis, in practiced hands, can be made with little risk, however, and is to be preferred, usually, to exteriorization or the establishment of an external fistula

How Much Small Intestine May Be Excised Safely?

A vital consideration in the proper conduct of extensive infarction of the small intestine is how much bowel may safely be excised compatible with subsequent good health

Flint has studied this problem experimentally and concluded that as

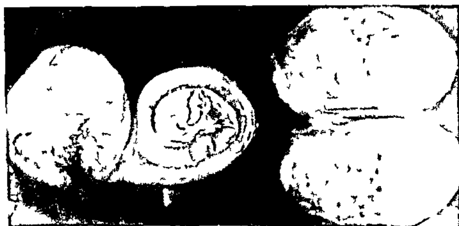


FIG 143—Large fibromyxosarcoma necessitating excision of a long segment of small intestine The tumor involved the superior mesenteric artery just beyond the branches of the first few jejunal and the right colic artery 360 cms of small intestine were excised Four years previously an extensive resection (75%) of the stomach was done for carcinoma

much as 50 per cent of the total small intestine of the dog may be removed without persistent untoward effects At first, the animals suffer from a severe diarrhea ravenous thirst and appetite There is usually severe weight loss which is only gradually recovered from and the dogs usually remain extremely sensitive to unfavorable conditions of diet and living Such animals should be maintained on a high carbohydrate and poor fat diet Protein is not utilized as fully as normally but in the presence of a diet rich in fat dogs deprived of half or more of their small intestine exhibit marked increase of nitrogen excretion in the feces Resections of 75 per cent and even more of the total small intestine may be survived, but such animals are unlikely to show a true recovery Only infrequently is the normal weight and a good compensatory assimilative process attained

According to Flint, a compensatory process consisting in hypertrophy

Moynihan has collected 51 resections of the small intestine all than 192 centimeters in length, all of which patients with a single tion made a successful operative recovery * Many died subseq however, of a marantic condition Watson was able to find 73 c resection of more than 200 centimeters of small intestine reported literature, and Brenzier has recently added a case of his own and other scattered reports to Watson's series

Treves measured the small intestine in 100 bodies and found the a length in the adult male to be 22 feet, 5 inches (683 centimeters 23 feet, 4 inches (706 centimeters) for the adult female The sl intestine was 15 feet, 6 inches (471 centimeters), the longest, 31 inches (960 centimeters)—a difference of more than 16 feet (489 meters) Feldman states Merola found only 80 centimeters of small tine in a man of 60

The most extensive resection of small intestine recorded to dat performed by Jerrauld, who excised 19 feet (579 centimeters) of intestine for gangrene caused by an embolus of the superior mes artery The patient was subsequently operated upon by Washbu intestinal obstruction due to adhesions, at which time 10 feet (305 meters) of small intestine remained In the joint publication made l two authors, the patient was reported to complain of periodic sp diarrhea but at the last examination 3 years after the first ope the patient weighed 5 pounds more than before the initial operation

A patient operated upon by Doerfler appears to have survived on maining portion of small intestine so short that Doerfler is prompt ask whether man may live without the small intestine He resect feet 8 inches (560 centimeters) of small intestine for a volvulus of tl tire small bowel of 30 hours' standing Twelve centimeters remaine low the duodeno jejunal juncture and 20 centimeters above the c Six and a half years later, when Doerfler made his report, the patien in good health and partook of food only at regular mealtime an in ordinary amounts, his bowels moved normally twice a day For time immediately following the operation, however, the patient was tressed by bowel movements every four hours and was considerably turbed by gas, he had then found it necessary to eat something every hours

Denk has reported an instance in which Brenner excised 18 feet centimeters) of small intestine in the operative cure of a strangu hernia Two and a half months as well as a year and a half after op tion, absorption experiments demonstrated a mild disturbance in the

* Unsuccessful cases are reported rarely

sorption of fat The patient maintained his weight of 48 kilos, however, and only complained of a moderate diarrhea Shortly after the second observation, the patient appeared to decline and lose in strength and weight and developed real hunger despite the liberal ingestion of food Death occurred two and a half years after operation At that time the weight was only 26 5 kilos At postmortem 3 feet, 5 inches (106 centimeters) of small intestine remained In a man aged 68, Mr S O, University Hospital, #649203, the writer excised 360 centimeters of small intestine in the removal of a large fibromyxosarcoma which involved the superior mesenteric artery just beyond the first jejunal and the right colic artery (Fig 143) All of the small intestine except about 150 centimeters was removed Four years previously, the writer had performed subtotal gastric resection for carcinoma of the stomach The patient died of coronary thrombosis two months after dismissal from the hospital In another patient, the writer excised 180 centimeters of small intestine for multiple lymphosarcomas, constituting about two thirds of the entire small intestine (Fig 89, p 295)

Reginald Jackson records the excision of 4 feet, 8 inches (142 centimeters) of the small intestine in a two year old boy for acute intestinal obstruction due to a strangulation of a portion of the intestine through a congenital opening in the root of the mesentery During the year immediately following the boy's life was often despaired of because of the frequent stools (seven or eight a day), at the time of the report, seven years after operation, the boy was well except for occasional attacks of diarrhea

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SUBJECT INDEX

(The numerals in bold print refer to pages in text where the subject matter is discussed at some length)

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